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UNION OF SOUTH AFRICA

DEPARTMENT OF MINES

CORUNDUM

IN THE

UNION OF SOUTH AFRICA

BY

W. KUPFERBURGER, D.Sc.

PUBLICATION OF THE GEOLOGICAL SURVEY DIVISION

PRINTED IN THE UNION OF SOUTH AFRICA
BY THE GOVERNMENT PRINTER, PRETORIA.
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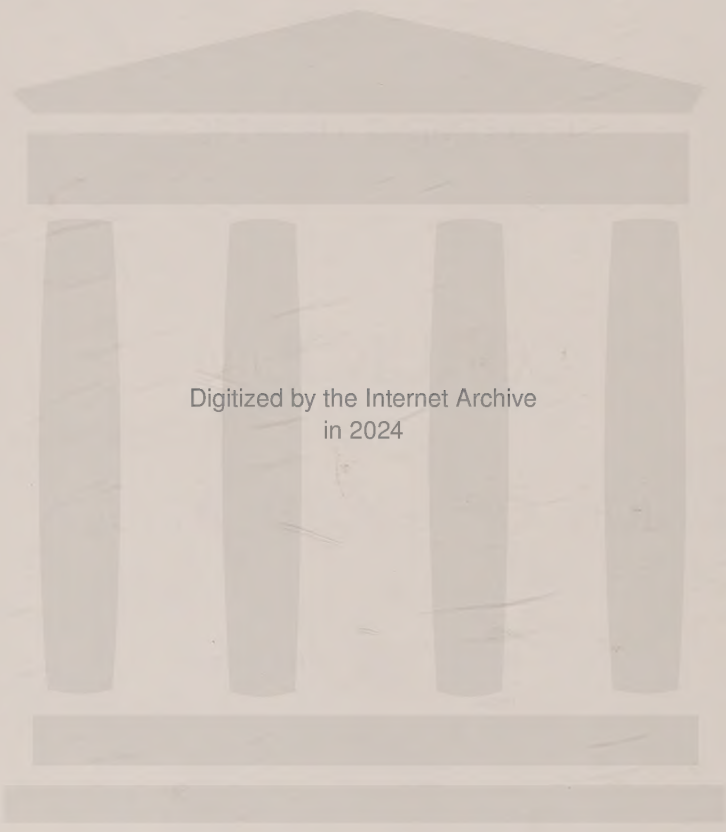
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Corundum in the Union of South Africa, with Special Reference to The Northern Transvaal Deposits.

CHAPTER I.

INTRODUCTION.

1. *General.*

“Corundum” is the name given to a crystalline mineral of which the chemical composition is aluminium oxide.

Next to the diamond it is the hardest natural mineral known and it is to this property that it owes its principal industrial use, namely, as an abrasive and a raw material for the manufacture of abrasive tools.

Corundum and emery, which is essentially a mixture of corundum and magnetite, are the principal natural mineral raw materials used as “hard” or “high-grade” abrasives. Competitive materials in this field are the manufactured products, silicon carbide and artificial corundum or fused alumina.*

For many years the Union of South Africa has been the leading producer of natural corundum, while most of the emery used in the world comes from the islands off the coast of Greece, Asiatic Turkey and the United States of America.

The manufactured or artificial abrasives are produced on a large scale in the United States of America, Canada and several European countries and are at present used in greater quantities than any of the natural mineral abrasives.†

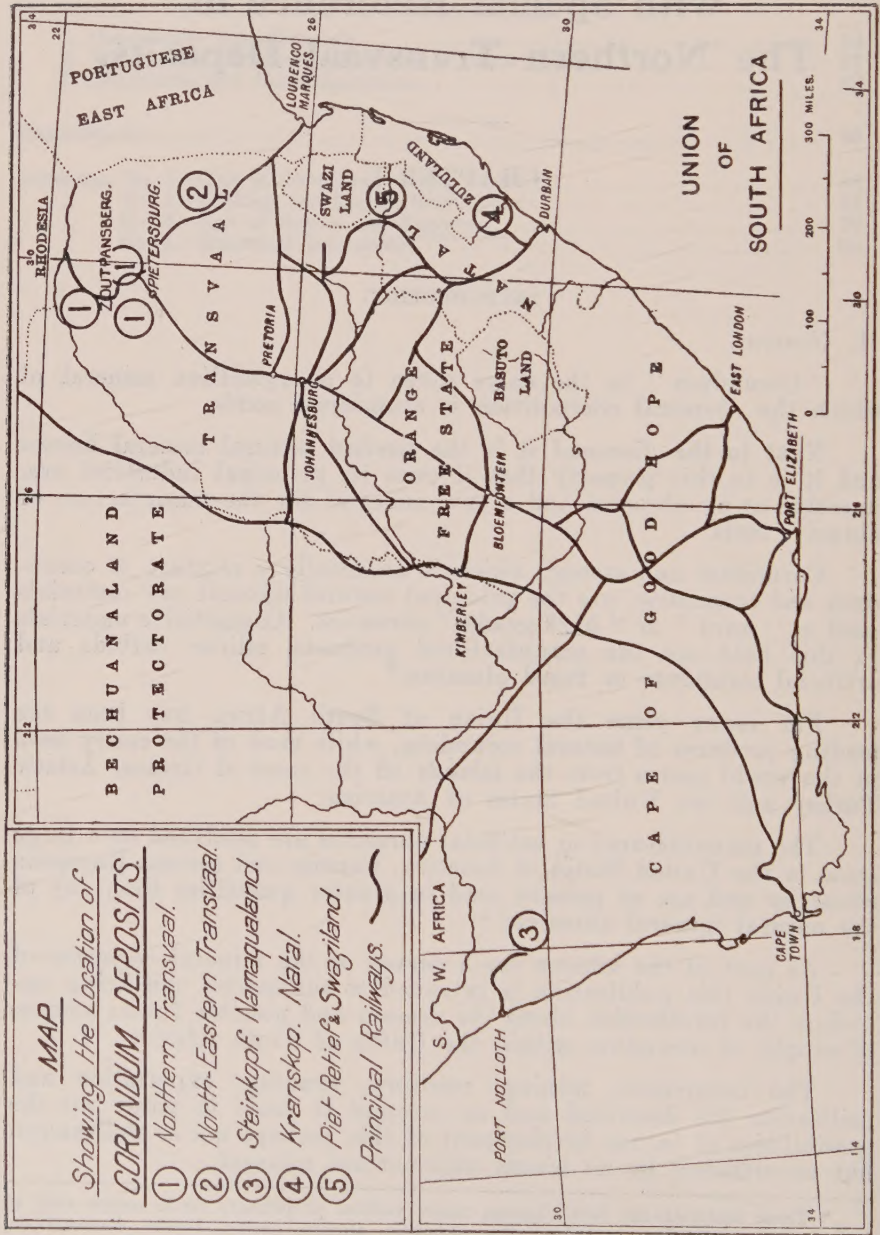
As part of the scheme for a survey of the mineral resources of the Union this publication is intended to summarise and bring up-to-date the information about the present and possible future sources of supply of corundum within the Union of South Africa.

The occurrence, mining, recovery, grading, exportation and utilisation are described and an attempt is made to point out the possibilities of future development of this perhaps not so well-known but nevertheless by no means unimportant mineral.

* These materials are better known under various proprietary trade names such as carborundum, crystalon, carbolon, sika, alundum, aloxite, exolon, lionite, borocarbene, abrasite, etc.

† Statistical information. Appendix No. 4.

2. Location of Corundum Deposits.



Corundum deposits of economic importance in the Union of South Africa have hitherto been found only in the areas occupied by the old granites and gneisses and the rocks of the old "Primitive Systems" into which the former are intrusive.

The deposits from which the bulk of the production has been derived in the past and from which it is being obtained at present are located in the northern and north-eastern Transvaal, distributed over an area more than 3,000 square miles in extent, embracing portions of the magisterial districts of Pietersburg, Zoutpansberg, Letaba and Lydenburg.

Small quantities of corundum altogether not more than 300 tons (see statistics quoted on page 29) have also been produced for export from a deposit near Steinkopf, in the district of Namaqualand, C.P. Corundum deposits are also known to occur in Swaziland,* in the south-eastern portion of the Piet Retief district, Transvaal † and near Kranskop, Natal.‡

Besides these are a number of other localities at which occurrences of corundum, of academic interest but of no economic importance, are known to exist.

CHAPTER II.

NORTH AND NORTH-EASTERN TRANSVAAL.

1 *Areal Distribution of Corundum Deposits.*

The corundum-bearing areas as at present known in the northern and north-eastern Transvaal are shown on the accompanying sketch map.

It will be noted that there are three well-defined and separate tracts.

In his Memoir, Hall§ recognises three regions characterised by differences in physiographic features as well as by the general nature of the corundum deposits:—

1. *The Plateau region*, west of the Pietersburg-Louis Trichardt railway.
2. *The "Transition" region*, east of the Pietersburg-Louis Trichardt railway and continuous with the Plateau region.
3. *The "Low Country" region*, east and south-east of Leydsdorp.
4. To these a fourth region, namely that north of the Zoutpansberg, can now be added.

* Bibl. No. 8.

† Bibl. No. 10.

‡ Bibl. Nos. 3 and 4.

§ Bibl. No. 6.

The largest and most important tract is that which includes both the Plateau and the Transition region and which extends between Louis Trichardt in the north, Pietersburg in the south, the Magabeen mountains and the Blaauwberg on the west, and the Kruger National Game Reserve on the east.

No discoveries of corundum have been reported from west of the extension of Waterberg rocks constituting the Magabeen mountains and the Blaauwberg. On the eastern side corundum is found within a few miles of the western boundary of the Kruger National Park, and is known to occur within the Game Reserve, but as no prospecting or mining is allowed there any deposits that may exist in that area cannot be taken into consideration.

In the "Eastern" or "Low Country" region extensive deposits of corundum occur in the tract of country between Selati and Olifants rivers and further eastwards towards the Malelane river, as well as on some farms south of the Olifants river.

Within recent years some deposits have been opened up on a number of farms north of the Zoutpansberg, and several other discoveries have been reported in a belt of country stretching N.E. and S.W. from the neighbourhood of Tatchan Kop through Lilliput to Messina. Corundum is also reported to occur beyond the Limpopo in Southern Rhodesia not far from the border.

The outer limits of the whole northern Transvaal area may therefore roughly be taken as the Limpopo river, near Messina, in the north, the Magabeen mountain on the west, the Kruger National Game Reserve on the east, and Pietersburg on the south.

The total area is large—well over 3,000 square miles in extent—and the individual deposits are relatively small and scattered over a large number of farms. On many farms there are several deposits. In Appendix No. 1 a list of farms on which deposits of corundum are known to occur or have been reported to occur is given. More than 300 farms are listed.

2. General Geology of Corundum-bearing Area.

In this widespread area the rocks with which the corundum deposits are associated can be classified briefly as follows:—

- (1) Dark-coloured basic-rocks, more usually massive than schistose, including *serpentines* and a large variety of rocks composed essentially either of amphiboles or pyroxenes or both, to which the general name of *perknites* can be applied.
- (2) Rocks of the old granite-gneiss group, and accompanying pegmatites and quartz veins.

The latter group is younger and has an intrusive relationship to the rocks of the former.

These rocks collectively are exposed over the greater part of the northern and north-eastern Transvaal except where they are covered over by younger formations, such as the rocks of the Waterberg system which constitute Zoutpansberg, Blaauwberg and Magabeen mountains, and the rocks of the Karroo system which flank the Zoutpansberg on its northern side and also occur as outliers of varying

extent further to the north, and west of Messina. The older basic rocks occur as infolded isoclinal masses of varying extent scattered throughout the area and separated from each other by granite and gneiss.

The pegmatitic intrusions into these rocks have in general followed the directions of schistosity and gneissic banding, and even the very much later doleritic dykes conform to a large extent to the trend of the older formation.

The main trend-lines of these ancient rocks as revealed by the following structural features—

- (i) the somewhat coarse schistosity of some of the basic rocks,
- (ii) the banding of the gneisses,
- (iii) the strike of the larger pegmatite intrusions,
- (iv) the alignment of the later doleritic dykes,

are not constant in direction over the whole area but can be generalized as follows: South of Pietersburg the strike of the Swaziland rocks of the Mount Maré area (as recorded by Hall) conforms to that of the Murchison Range namely E.N.E.-W.S.W. North of Pietersburg, in the neighbourhood of Bandalier Kop, the predominant direction is E.-W. East of the railway line it swings round to E.N.E.-W.S.W. again. Between the Sand river and the Blaauwberg, N.W. of Pietersburg, the trend lines vary between W.N.W.-E.S.E. and N.W.-S.E. North of the Zoutpansberg, N.E.-S.W. and E.N.E.-W.S.W. again become the predominating structural directions.

Within the granite-gneiss group are included rocks that are probably of different ages. In places the granite is gneissic and merges into gneisses containing minerals such as garnet, sillimanite, amphiboles, and often an abundance of dark-coloured mica indicating the absorption of basic material. In other places again there are granites without any gneissic structure. It seems highly probable that some of the massive granite occurrences, such as that which forms the prominent koppies through which the main north road passes on De Gladde Klip Kop (114) south of Matoks Location 30 miles north of Pietersburg, are of later age and similar to the Palabora granite in the eastern Transvaal.

3. *Physiography.*

The country to the north and north-west of Pietersburg is an old peneplain with an elevation above sea-level ranging from just over 3,000 feet near Pietersburg to 2,000 feet along the Limpopo river. The slope is gradually northwards except where it is broken by the Zoutpansberg and Blaauwberg, built up of younger Waterberg rocks, which rise to over 5,000 feet above sea-level.

The principal drainage system is that of the Sand river, with its tributaries the Hout river and Brak river, flowing northwards and entering the Limpopo a few miles north-east of Messina.

The Brak river flows through the wide gap on the Waterberg rocks dividing the Blaauwberg from the Zoutpansberg. The con-

fluence of the Hout river and the Sand river is a few miles south of the gorge cut by the latter through the Zoutpansberg between Mara and Waterpoort.

Rising out of the peneplain there are occasional residual hills. Loskop on the farm De Loskop No. 127 is a small outlier of Waterberg sandstone supported by one of a series of parallel dolerite dykes striking W.N.W.-E.S.E. A few miles west is Kameelkop, also composed of dolerite, on which a trigonometrical survey beacon is situated. Similar dolerite ridges occur on Brakspruit (313), Waerkum (717), Houtrivier (993), and Sodom (992).

Dark-coloured coarse-grained gneiss builds high ground on Grutz No. 740 and Sliedrecht No. 741 and also the irregular cluster of hills known as Bandolier Kop close to the railway station of the same name.

On the farm Groothoek No. 753 there is a bare, rounded outcrop of fine-grained and light-coloured garnetiferous gneissic-granite. It is known locally as " Witklip " and is a prominent landmark in the otherwise featureless landscape for miles around.

In several other localities, notably Palmietfontein No. 374 and De Gladde Klip Kop No. 114, there are clusters of rocky koppies built up of granite.

About 7 miles south-west of Louis Trichardt there are some low rocky hills of serpentine, close to the common beacon of Ledig No. 946, Nooitgedacht No. 308, and Senthimula's Location No. 456. The high ground south-east of Louis Trichardt on Rondebosch No. 30 and Vygeboomspruit No. 72 is also marked by prominent serpentine outcrops.

Except for these occasional residual hills the surface of the peneplain is generally flat or gently undulating and covered by a variable thickness of overburden composed of sand and fragments and boulders of the harder and more resistant rocks. Outcrops are scarce and the tracing of the actual line of demarcation between the masses of older basic rocks—perknites and serpentine—and the granite or gneiss is generally impossible. The basic rocks are, however, usually covered by a deep reddish brown soil. Occasional grey to brownish black boulders or in situ outcrops with characteristic pitted surface may be seen protruding through the soil. The soil of the granitic and gneissic rocks is generally lighter in colour and much more sandy. In the neighbourhood of dolerite dykes deep red and sometimes black, clayey soil is found.

East of the Pietersburg-Louis Trichardt railway line, north of Munnik station, the country becomes more highly dissected as a result of the erosion by the easterly flowing streams of the Klein, Middel and Groot Letaba river system.

This highly dissected region, known locally as the " Spelonken ", is the northerly continuation of the Woodbush escarpment, and forms the transition belt between the upper peneplain or Plateau region and the " low country " peneplain which extends eastwards as far as the Lebombo range. The average elevation of this low-country peneplain is at least 1,500 feet lower than that of the upper plateau.

CHAPTER III.

GEOLOGY OF THE CORUNDUM DEPOSITS IN N. AND N.E. TRANSVAAL.

Corundum occurs in original or primary deposits—so-called “reef” corundum—and in secondary or detrital deposits derived from the former by weathering and sub-aerial denudation—“eluvial” corundum.

1. *Primary Deposits.*

In the primary deposits the rocks in which the corundum is found display a good deal of variation in mineral composition but nevertheless have several features in common in their geological relationships and mode of origin. Three main types can be recognised.

- (a) *Plumasites*, which are rocks composed essentially of felspar and corundum. In places other minerals, the commonest of which is dark-coloured mica, are present in varying proportions.
- (b) *Marundites*.—This name was coined by Hall * for rocks composed essentially of margarite and corundum with subordinate amounts of felspar.
- (c) *Migmatic corundum-bearing rocks or corundum gneisses*.—In this category are included a variety of rocks displaying some degree of gneissic structure and composed of felspar, corundum and dark-coloured mica and occasionally hornblende in varying proportions.

Many gradations between these three types of corundum-bearing rocks exist.

There is little doubt that all these rocks in which corundum occurs as a primary constituent are genetically related to the intrusion of the residual pegmatite magma of the old granite into the masses of basic rocks into which the granite itself is intrusive. Pegmatites associated with the old granite are of common occurrence and are normally quartz-felspar pegmatites. Corundum was apparently formed only under certain favourable conditions, for it is found only where the pegmatitic magma invaded the basic rock masses included in the granite. This is borne out by field evidence. In all the corundum deposits examined in the hundreds of workings over the whole area, the country rock, where exposed, is always one of the varieties of basic rocks and in many cases a definite relation to a pegmatite intrusion can be made out. The strike of the pegmatite intrusions with a few exceptions coincides with the foliation of the country rock. The parent rock of the corundum is pegmatitic in character as in the plumasites and marundites or at least closely associated, as in the migmatic corundum-bearing rocks, with the intrusion of pegmatitic magma.

* Bibl. Nos. 5 and 7.

This genetic relationship was pointed out by Hall in his description of the northern and eastern Transvaal corundum occurrences.* According to du Toit † a similar relationship exists in the corundum-bearing rocks near Kranskop, Natal, and Rogers ‡ refers to the possible connection between the corundum found in the gneissic rocks near Steinkopf and the intrusive microcline pegmatites of that area.

The invariable association of corundum deposits with pegmatite intrusions into basic rocks led du Toit † in explaining the Kranskop occurrences and Hall* those of the northern and eastern Transvaal to formulate the theory of desilication of the pegmatite magma by interaction with the basic rocks into which it was intruded. The result of this was to give rise to an alumina-rich magma from which corundum eventually crystallised. This was accompanied by the metamorphism of the basic rocks, the commonest alteration products being biotite, hornblende and talc, and in places by later hydrothermal changes effected in the intrusive corundum-bearing rock and the wall rocks as well. All the endomorphic and exomorphic effects accompanying these intrusions which were responsible for the origin of the corundum and the individual differences in the various deposits need not be discussed here in detail as that would necessitate a great deal of detailed chemical and petrographic analysis. It is sufficient to state that this explanation is supported by field evidence in the majority of the deposits and as a broad basis affords the best working hypothesis in prospecting for corundum especially over the large areas where the details of the underlying geological structure are largely obscured by a mantle of residual overburden.

No deposits of corundum have yet been found in areas where the granite is entirely free from inclusions of basic rocks. The recognition of this fact has led prospectors and diggers to look upon the occasional boulder-like outcrops of basic rocks as favourable "indicators" of the likely presence of corundum deposits, especially in the proximity of any traces of pegmatite intrusions. The pegmatite intrusions could be similarly used as indicators but with a few exceptions they are small in size and rarely form prominent outcrops in the northern plateau region. It must be borne in mind here that we are dealing with an area that is a very old land surface which has undergone a great deal of sub-aerial denudation.

(a) *Plumasite Deposits.*

Of the primary occurrences the plumasite deposits are the commonest and the most important on account of their widespread distribution in the northern Transvaal area.

Important deposits of this type exist and have been opened up on Turkaspost No. 941, Bultfontein No. 863, Palmietfontein No. 374, Stukfontein No. 2624, Ballymore No. 106, Wyllie No. 1012, Bouw No. 722, Grutz No. 740, Proserpina No. 719, Waerkum No. 717, Brakspruit No. 313, Mampakuil No. 225, Wurthsdorp No. 1023, Koniggratz No. 1022, Westphalia No. 1021, Witten No. 1027, Munt No. 1026, Buiksloot No. 1053, Ringfontein No. 934, Blinkwater No.

* Bibl. Nos. 5 and 7.

† Bibl. Nos. 3 and 4.

‡ Bibl. No. 2.

1037, Wildebeestkuil No. 213. This is by no means an exhaustive list and on many other farms deposits exist and have been discovered in the course of excavating the overburden to recover eluvial corundum.

The typical plumasite is a rock composed of white felspar belonging to the acid end of the plagioclase series (albite to andesine) and dull grey crystals of corundum. Black or dark brown mica is the commonest additional constituent. A dark green amphibole was noticed in a body of plumasite opened up on Wolferoode No. 311. In a deposit on de Lange's portion of Blinkwater No. 1037, as well as on the adjoining farm Fraaigezicht No. 1035, the mineral sapphirine occurs in well formed flat crystals and several inches in length. In several deposits irregular masses, sometimes encrusting crystals of corundum, of a dark, bluish material which appears to be a fine grained aggregate of magnetite and spinel, are present.

The corundum is generally imbedded in felspar and occurs in well formed crystals and in partly formed crystals with angular outlines. The crystal habit varies considerably in different and sometimes in closely adjoining deposits but this feature will be discussed elsewhere.

The proportion of corundum in plumasite may be as high as 80 per cent. of the volume of the rock in what is locally known as "boulder corundum" or on the other hand the corundum may be present only as occasional scattered crystals constituting less than 5 per cent. of the rock.

The average size of the crystals of corundum in the various deposits varies within wide limits. Being pegmatitic in character the plumasites are generally coarse grained in texture. Some exceeding large crystals of corundum (weighing up to 300 lb.) have been found, but they are exceptional. The majority of crystals seen range from half an inch to four inches in length. The plumasites are definitely pegmatitic in character and instances are known where within a single intrusive body there is a gradation from ordinary quartz-felspar pegmatite through felspar without quartz to corundum-bearing felspar or plumasite. In some deposits this change can be followed from the middle outwards. Even when the body of the intrusion consists entirely of plumasite there is sometimes a concentration of corundum along the contact or within a few feet of the outer margin of the deposit.

This rough bilateral symmetry observed in the case of many plumasite deposits indicates that the desilication of the pegmatite magma took place in situ. This assumption is further supported by the presence, in the case of nearly all deposits examined, of a zone of schistose mica followed by a development of hornblende and talc along the contact of the plumasite with the basic country rock. The bilateral concentration of corundum along the outer margins of the lenticular plumasite bodies, which is an observed fact in many deposits and which is supported by the theoretical considerations concerning the genesis of the corundum, has not been appreciated everywhere in the course of mining and prospecting operations. In several instances it has been observed that diggers on finding a body of plumasite with a payable concentration of corundum along one

contact, have gone down as far as possible until the corundum diminished in quantity or the rock became too hard for profitable mining and have not tested the possibility of finding a similar payable concentration on the other side of the body along the contact with the basic country rock.

In one or two instances, such as the well-known deposit on Palmietfontein No. 374, large bodies of plumasite occur in which the corundum is more or less evenly distributed throughout the whole intrusion. In such cases it is believed that the desilication must have taken place prior to the intrusion of the magma into its present position.

(b) *Marundite Deposits.*

The primary deposits of this type are found chiefly in the eastern Transvaal corundum-area and in their geological relationship are similar to the plumasites of the northern area.

The typical marundite is a coarsely crystalline rock in which the corundum is embedded in scaly and frequently rosette-shaped aggregates of margarite. The margarite has a pearly lustre and is usually pale greyish-white or pinkish-white in colour. Felspar, biotite, apatite, garnet and tourmaline are accessory minerals.

The marked petrological difference seen in the presence of margarite in the place of felspar as the principal constituent associated with the corundum is explained by Hall* as being due to hydrothermal alteration of plumasite shortly after the intrusion of the pegmatite magma and the development of originally normal plumasite. The conversion of the felspar to margarite was accompanied in some cases by the partial metasomatic replacement of the corundum on the outside of the crystals and also to some extent along cracks and parting planes by gibbsite and margarite in fine-grained scaly aggregates. In the larger crystals there is often a well-defined reaction border of these minerals with a solid core of corundum, giving rise to what Hall described as "egg corundum". In some deposits complete pseudomorphs of small crystals are found.

This hydrothermal alteration is naturally detrimental to the quality of the corundum from an abrasive point of view, and for this reason the corundum from some of the deposits in the eastern Transvaal is unsuitable for export. In some other deposits, however, the intensity of the hydrothermal action has not been sufficient to affect the corundum to any marked extent and some exceedingly good corundum, suitable for export, has been produced from that area.

In the northern Transvaal area effects of similar hydrothermal conditions are to be seen at deposits on Laatste Hoop, south-east of Pietersburg, and on Gordon, north of the Zoutpansberg, to lesser extent on Wolferoode and at several other deposits.

According to du Toit† the corundum deposits in the neighbourhood of Kranskop, Natal, belong to this type.

* Bibl. No. 7.

† Bibl. Nos. 3 and 4.

(c) *Migmatic or Gneissic Deposits.*

The corundum deposits of the gneissic or migmatic type are not as common or as widely distributed as the plumasites but nevertheless are represented by several important deposits and a few smaller occurrences in the northern Transvaal.

The deposits near Steinkopf, Namaqualand, described by Rogers* apparently also belong to this type.

The principal occurrences of this type in the northern Transvaal are situated on the farms Blinkwater No. 1037, Borkum No. 1019, Uitzoek No. 1935, Kaaldraai No. 835, Blydschap No. 834, Rooikop No. 23, Gordon No. 929. On the farm Van Wyksput No. 841, 5 miles west of Loskop, there is a small and as yet unexploited occurrence of this type exposed on the southern side of a small pan next to the road from Kalkbank to Bochem via Brussels and Koekkoek.

In all these deposits, except those on Gordon, the corundum-bearing rock is a felspar-biotite gneiss. On Gordon bornblende is the principal ferro-magnesian mineral but biotite is also present. The corundum which is usually in beautifully idiomorphic (prismatic or barrel-shaped) crystals is generally surrounded by felspar and set in a finer-grained matrix of biotite and felspar. The matrix displays gneissic banding and is finer in texture than the average plumasite. In addition to the larger idiomorphic crystals of corundum smaller crystals and minute grains of corundum occur in the matrix.

The deposits of this type have the form of irregular and sometimes curved lenticular bodies bounded by serpentine or perknite and are invariably associated with intrusions of pegmatite. In some deposits, e.g. on Blinkwater and Borkum, masses of quartz-felspar pegmatite are seen at one end or along one side of the corundum-bearing zone. Occasionally also lens-shaped masses of pure felspar up to 10 feet in thickness and "schlieren" of schistose biotite are found within the body of corundum gneiss. Along the contact with the serpentine or perknite there is generally a thin veneer of schistose mica. At Rooikop a narrow vein of pegmatite which graded into corundum plumasite along its northern contact with serpentine developed within 10 feet of the surface into a flat-dipping lense of corundum gneiss composed of large crystals of corundum closely packed together imbedded in biotite with spinel and magnetite and comparatively little felspar as accessory minerals.

At the deposit on Gordon the country rock is a gneiss composed of hornblende, felspar and biotite and the corundum is concentrated along a zone a few feet wide on either side of a narrow pegmatite composed principally of microcline-perthite, hornblende and biotite.

The deposits at Kaaldraai and Blydschap were not visited by the writer, but specimens of the corundum-bearing rock from these deposits in the Geological Survey collection are very similar to those from Borkum, Blinkwater and Van Wyksput. According to the description by Hall† these deposits are also intimately associated with pegmatite intrusions. The difference in character between the normal plumasite and the corundum gneisses in spite of the similar mode

* Bibl. No. 2.

† Bibl. No. 5.

of origin of the corundum is no doubt due to the fact that the emplacement and solidification of the rock took place under different local conditions. In the case of the corundum gneisses the intrusion of the pegmatite magma was probably accompanied by local differential movement caused by laterally directed pressure which caused the intimate injection of the already partly desiccated but still highly fluid pegmatite-magma into the basic country rock.

In the case of the normal plumasites there is no evidence of pronounced movements or pressure effects other than those produced by the intrusions themselves.

(d) *Boulder Corundum.*

Associated with many of the primary deposits, more particularly of the plumasite and marundite type, outcrops of detached boulders containing a high percentage (50-80) of corundum are commonly found. Similar rocks are also found in places deeper down below the surface in many of the reef workings. There is no doubt that they represent portions of the plumasite or marundite "reef"-rock in which corundum is highly concentrated. No sharp line of demarcation between this hard and so-called boulder corundum and the ordinary corundum-bearing "reef"-rock can be drawn.

The name "boulder corundum" has been given to this type of material on account of its common occurrence in the form of detached rounded masses of different sizes at the surface. Its occurrence in this form is due to its greater resistance to weathering as compared to the other portions of the deposits containing less corundum.

Boulder corundum is generally composed of contiguous and interlocking crystals of corundum with subordinate amounts of felspar, mica and other associated minerals filling up the interstices.

2. *Form and Extent of the Primary Deposits.*

The primary deposits of corundum-bearing rock generally occur as roughly lenticular intrusions of irregular narrow veins within one or other of the masses of dark coloured basic rocks previously described. In places, as for instance the well-known deposit on Palmietfontein No. 374, about 12 miles south-west of Louis Trichardt, the shape of the body of plumasite is more like that of a plug. The disposition of the deposits is usually vertical or nearly so but in the narrow vein-like bodies inclinations as low as 25° to the horizontal plane are occasionally met with.

Deposits are variable in width and show the typical pinch-and-swell behaviour, both vertically and horizontally, characteristic of many pegmatite intrusions. Widths of from a few inches up to 25 feet have been noted.

The strike of the deposits with few exceptions conforms to that of the main trend lines of the area as shown by the gneissic banding, foliation and direction of the major joint planes in the adjoining rocks.

The greatest length of any single intrusion, or more strictly, series of probably continuous intrusions, observed in any of the workings is in the neighbourhood of 200 feet (Turkaspost-Bultfon-

tein). In places, however, there is an "en echelon" alignment of several deposits extending over a distance of several miles. This is particularly well illustrated by the deposits on the farms Potsdam, Wurthsdorp, Koniggratz, Westphalia, Cumbrae and Borkum, and those on Turkaspost, Bultfontein, Kaaldraai and Benaauwdheid.

As regards vertical extent there is not much direct evidence. A few of the workings, on Blinkwater, Borkum, Westphalia, Turkaspost, have been carried down to close on 100 feet, but in the majority of deposits that have been opened up the workings have not penetrated to more than 20 feet from the surface. From the behaviour and shape of the deposits at the surface it can be assumed, and the assumption is supported by the direct evidence afforded by the deeper workings, that the corundum-bearing deposits are irregularly lenticular in the vertical as well as in the horizontal direction.

In view of the intrusive nature or origin of the deposits it would therefore be reasonable to assume that while individual bodies narrow down in depth and pinch out completely, other similar bodies will be found to at least such depths as the included basic pendants within the granite extend. The depth limit to which these masses will be found in the granite cannot be estimated with any certainty. In the low country of the eastern Transvaal where the present erosion level is anything from 1,000-2,000 feet lower than that of plateau area of Zoutpansberg district, similar included basic rock masses in the old granite are still numerous. It would therefore be reasonable to assume that they are likely to extend to at least 1,000 feet below the present surface level in the northern plateau area.

It is, unlikely, however, that mining for corundum to such depths or to more than 100-200 feet will ever be found economically feasible. The question therefore resolves itself into the possible limits of extension in depth of the particular deposits encountered at the surface. For this the determining factors are the original size of the deposit, and its position relative to the present surface level.

As regards the first factor there is some direct evidence in the numerous deposits that have been opened up. In some of the narrow vein-like bodies, e.g. Brakspruit, Westphalia, the vertical distance to which they have been opened up is greater than the distance along which they have been traced at the surface. In the majority of workings, however, the reverse is true, but it must be borne in mind that not a single deposit can be said to have been completely worked out or even explored to its absolute limits.

In all cases where deposits have been abandoned there have been other causes, for instance:—

- (i) The rock may have become too hard for easy mining.
- (ii) The digger may have found a more productive deposit elsewhere.
- (iii) The cessation of working on a deposit may have been due to a slump in the corundum market, a not infrequent occurrence in the past history of the corundum industry.

The size of individual corundum deposits varies within wide limits. No accurate record of mining or of the production of corun-

dum from any deposits has been kept. Moreover as stated previously few if any deposits have been explored to their limits. Any estimates of the size of deposits based on the evidence of present and former mining operations must therefore be approximate. An estimated size of anything in excess of 10,000 tons for any individual deposit would not be justified by the observed facts. Of the deposits known at present there are probably less than a dozen of between 10,000 and 5,000 tons and the size of the majority fall between the limits of a few hundred to a thousand tons of corundum-bearing rock, the average corundum content of which would not be in excess of 40 per cent.

As regards the second factor, this is likely to be different for each individual deposit, and therefore it cannot be determined except by actual mining development. Cases are known where it is fairly obvious from the presence of a large concentration of eluvial corundum and a relatively small underlying reef deposit that the latter is the basal portion of an originally larger deposit that has been denuded. In other cases comparatively small and apparently insignificant veins of plumasite have opened up in depth to large bodies—or one or more narrow vein-like intrusions have coalesced to form a single large body some distance below the present surface.

3. *Secondary or Eluvial Deposits.*

Corundum is highly resistant to the processes of weathering and is therefore found in secondary or detrital deposits wherever primary corundum-bearing rocks occur.

The area in the northern and eastern Transvaal in which the primary corundum-bearing rocks just described occur is an extremely old land-surface which has probably been in existence as such since Jurassic times if not earlier and has been subject to sub-aerial denudation over this long period of time. It is not surprising, therefore, that extensive accumulations of corundum crystals, which have been liberated from the various types of parent rocks by the natural processes of rock disintegration, are found in the northern and eastern Transvaal. These now constitute the eluvial deposits. Except in one or two instances there is no evidence of the transportation of the corundum, by running water or any other agent of transportation, over long distances. In most cases it occurs in the residual soil immediately above or in close proximity to the bodies of reef corundum from which it has been derived.

In many but by no means all the localities where eluvial deposits have been worked the parent rock or at any rate some of the primary bodies which have yielded the eluvial corundum have been discovered.

Some relatively small deposits of eluvial corundum have led to the discovery of large bodies of reef corundum. On the other hand several large and highly productive patches of eluvial ground have been worked through without revealing any large body of primary corundum bearing rock.

In view of the lenticular nature of the deposits and the probable occurrence of corundiferous lenses at various levels within the masses of basic rocks included in the old granite, this is to be expected. It is possible that some primary deposits occurring at higher levels than

the present surface, have been completely removed by denudation, leaving only the residual corundum and possibly the "roots" or narrow feeder-channels of the original deposit below the accumulated detrital material.

The type of ground in which the eluvial corundum is found depends on the nature and distribution of the older rocks in the immediate neighbourhood. It is usually a reddish-brown clay derived from one of the varieties of basic rocks in which the primary deposits occur. In places it is highly ferruginous and consolidated to ferricrete. Where the granite or some pegmatite is close at hand it may be more sandy or loamy. In places such as Leeuwkop and Preston there is a good deal of surface limestone and the eluvial corundum is found imbedded in calcareous tufa.

With the corundum in the eluvial deposits, pebbles and boulders of various other rocks are found, often in great abundance. Among these vein quartz, reddish quartzite and banded ironstone are the commonest. The red quartzite closely resembles some of the Waterberg quartzites found on the Zoutpansberg and Blaauwberg and indicates the probable former extension of the Waterberg formation over a large part of the northern plateau area. The occasional fragments of banded ironstone, fine-grained granite and garnetiferous gneissic-granite are derived from the old granite-gneiss group of rocks.

The occasional presence of a few odd fragments and crystals of corundum at the surface, where they have been washed out by heavy rains or thrown out by ant-bears, is often the only indication of the existence of a deposit of eluvial corundum and many of the deposits were discovered in that way.

The known occurrences of eluvial corundum are of more widespread distribution than those of the primary deposits and for many years the bulk of the production was derived from this type of deposit.

On many of the corundum-bearing farms only the eluvial corundum has been worked and its widespread distribution is seen in the large numbers of shallow open workings, many of them now abandoned, throughout the corundum-bearing area in the northern and eastern Transvaal. The individual workings vary in extent from a few square yards to several hundred square yards and are hardly ever more than four to five feet deep.

The concentration of corundum in the eluvial deposits varies considerably in different deposits as well as in different parts of individual deposits. Corundum may be present only as a few isolated crystals scattered through the soil in quantities not sufficient to repay working. On the other hand, in some deposits "pockets" have been found containing an extraordinarily high concentration of corundum. Several instances are on record (e.g. Oog-van-Doornrivier, Blinkwater, Beginsel, Munt, etc.), where such "pockets" yielding from 5 up to 100 tons of corundum were found in which the corundum crystals were packed together with a minimum of interstitial earth and rubble.

The lower limit of payability naturally varies with local conditions such as the cost of obtaining water for washing, the quality and average size of corundum recovered and the distance from railing point or depots. In the majority of the eluvial deposits that have been worked the average corundum content has been between 10 and 20 per cent. by volume of the earth treated. At the prices ruling at present and under the most favourable conditions of working it is doubtful whether any eluvial deposit with less than 5 per cent. by volume of corundum would be payable.

CHAPTER IV.

CHARACTERISTICS OF NORTHERN TRANSVAAL CORUNDUM.

1. *Physical*.—There is a good deal of variation in the physical properties such as colour, crystal form, twinning, fracture, etc., of the corundum found in the northern Transvaal. In many cases it is possible to tell the source of a crystal by the physical characteristics which are peculiar to the corundum from certain deposits.

Colour.—The colours most commonly found in the northern Transvaal corundum are as follows: greyish-white, pale and dark bluish-grey, blue, black, brown, reddish-brown and pink.

Lustre.—The lustre of the corundum is generally bright glassy to adamantine, occasionally with a metallic sheen. Where the corundum has been hydrothermally affected and either wholly or partly altered to gibbsite, margarite, etc., the crystals are usually green or greenish-grey in colour and have a dull or sometimes pearly lustre.

Crystal form.—Corundum crystallises in the rhombohedral system and the commonest crystal forms seen in the corundum from the northern Transvaal are as follows:—

- (1) Six-sided columns or prisms with flat, smooth surfaces at either end (basal pinacoid). This type of crystal may be either elongate or tabular.
- (2) Barrel-shaped crystals due to the development of one or more sets of steep rhombohedral faces and the basal pinacoid.
- (3) Steep hexagonal bi-pyramids or barrel-shaped crystals which taper to a point at either end. This form is similar to (2) but is without the basal pinacoid face.

The prismatic and steep barrel-shaped crystals, whether elongate or tabular, are characteristic of the gneissic deposits (e.g. Blinkwater, Borkum, etc.), or the plumasites in which mica is a prominent constituent (e.g. Palmietfontein and de Lange's Portion of Blinkwater). The steep bi-pyramidal crystals on the other hand are characteristic of the pure and relatively mica-free plumasites.

Distorted crystals and intergrowths of various types are common and many crystals display pronounced zonal structure. Polysynthetic twinning parallel to the unit rhombohedron is nearly always present

but not always equally pronounced. In a plumasite deposit on the farm Turkaspost where the corundum assumes a tabular habit the peculiar "arrowhead" or "herringbone" twin crystals are found.*

Cleavage.—Corundum normally has no true cleavage. In the northern Transvaal corundum a parting parallel to the basal pinacoid is well developed in the crystals from many localities. A less pronounced rhombohedral parting is also frequently seen.

With a few exceptions these parting planes are not sufficiently pronounced to affect the abrasive qualities of the corundum. For abrasive purposes sharp edges are required and good corundum should break with an uneven splintery fracture. Furthermore it should be sufficiently brittle to break up giving new sharp cutting edges when in use either as loose grains or when made up into grinding wheels.

Specific gravity.—The specific gravity of corundum is generally quoted as being from 3.90-4.15. In the crystal corundum produced in bulk for export there is naturally a slight variation in specific gravity of the corundum from different deposits depending upon the presence of inclusions or alteration products.

The following are the specific gravities of corundum crystals from some well known deposits:—

Palmietfontein	Sp. Gr.	3.90
Kaaldraai	" "	3.87
Bultfontein	" "	3.90
Brakspruit	" "	3.94
Uitzoek	" "	3.82
Blinkwater	" "	3.68

Hardness.—Corundum is the second hardest natural mineral known and has a hardness of 9 according to Mohs' scale. In the corundum produced in the northern Transvaal is a slight variation in hardness in crystals from different deposits. Any slight chemical alteration naturally reduces the hardness.

2. Chemical Composition.—Corundum is crystalline alumina (Al_2O_3); when quite pure it is colourless and transparent. Pure crystals with the theoretical composition are however not found as natural minerals. Even the gem varieties ruby and sapphire, which are the purest, contain traces, generally less than 1 per cent., of inorganic impurities to which the colour of these gemstones is thought to be due. The common varieties of corundum such as that found in the Transvaal contain relatively larger and variable proportions of inorganic impurities.

The following analyses quoted from Hall's Memoir (Bibliography No. 5) give the composition of the corundum from some of the Transvaal deposits:—

* Bibl. Nos. 5 and 14.

No.	Locality.	Al ₂ O ₃ .	SiO ₂ .	Fe ₂ O ₃ .	CaO.	MgO.	H ₂ O.	Total.
I	Palmietfontein.....	96·20	·55	·77	·27	·2	2·08	100·07
II	Kaaldraai.....	96·9	·22	·95	·11	·3	1·52	100·00
III	Bultfontein.....	94·18	3·70	·43	·14	·49	1·07	100·01
IV	Sable Camp.....	94·80	·26	1·30	·15	·41	3·06	99·98
V	Mixed Sample.....	93·07	3·69	FeO 1.51		·86	·87	100·00

No. V is the analysis of a composite sample from a consignment of corundum supplied by several producers and railed from Mara Station. It can be taken as fairly representative of "A" grade corundum as exported at present under the Grading and Export Regulations.* Although the lower limit of alumina content of the A grade is 92 per cent., percentages of well over 92 are frequently obtained in the analyses of samples taken from consignments for export. (See pages 37 and 38.)

Alteration.—Corundum is stable under ordinary atmospheric conditions and there is no trace of any chemical alteration, due to weathering, in the corundum of the eluvial deposits in the northern Transvaal.

The type of alteration found in the marundite deposits of the eastern Transvaal and some other deposits elsewhere, viz., the partial hydration of the corundum to gibbsite or the metasomatic replacement of corundum by gibbsite, margarite, spinel, magnetite, etc., took place under deep-seated, post-magmatic, hydrothermal conditions.

Impurities.—The impurities found in Transvaal corundum are due to two causes:—

- (a) The hydrothermal metamorphism of some of the corundum deposits. This has already been described;
- (b) The presence of small inclusions of various minerals. These represent small grains or crystals already present in the magma from which the corundum crystallised and which were caught up and enclosed during the growth of the corundum crystals. Small flakes of biotite are the commonest and more rarely other minerals such as ilmenite, spinel, magnetite, rutile, apatite, monazite are also found. When present in large amounts they render the corundum less effective for abrasive purposes and such deposits are not worked. Ilmenite and rutile in particular are undesirable when the corundum is to be used in the manufacture of specially pure fused alumina. Titanium more than any other impurity has the effect of making the prepared abrasive hard and tough so that when incorporated into the grinding wheels it is liable to become dull, when used, instead of continually fracturing with new sharp cutting edges.

* Appendix No. 2.

CHAPTER V.

OTHER DEPOSITS IN SOUTH AFRICA.

1. Namaqualand, C.P.*

About four miles east of Steinkopf corundum is found in the form of loose crystals in a strip of country about $4\frac{1}{2}$ miles long and up to 500 yards in width, extending in a north-north-easterly direction parallel to the foliation of the underlying gneiss and schists from which the mineral has been released by weathering. The crystals are collected by hand from a layer of soil and subsoil rarely exceeding 3 feet in depth. According to T. W. Gevers, corundum has also been recovered from a trench 10 feet deep in the underlying micaceous gneiss.

During the period 1913-1927 altogether about 300 tons of crystal corundum were recovered. (See Statistics, page 29). Since 1927 there has been no production.

The rock in which the corundum is found varies in character from a schist very rich in biotite through microcline-biotite gneiss to fine-grained quartz-biotite-microcline gneiss. These three varieties are interfoliated, especially the first two, but the third variety forms thick lenticular layers with very little intermixture of the other. The direction of foliation of the gneiss is approximately N. 30° E. The crystals are generally found lying parallel to the planes of foliation but also at various angles and even perpendicular to the foliation. In most cases the larger crystals are surrounded by a zone of pink microcline up to $\frac{1}{10}$ inch thick. The rocks are penetrated in various directions by coarse-grained pegmatites containing pink microcline similar in appearance to that found round the corundum crystals. Crystals of corundum are reported to have been found in the pegmatites. As far as can be judged from the exposures the corundum is not more abundant near the pegmatites than at a distance of many yards from them yet the very general association of microcline with corundum crystals in the gneiss points to a genetic connection between the two.

The corundum crystals generally have the form of acute six-sided bi-pyramids and crystals up to 8 inches in length have been found. The corundum is opaque and has a greenish tinge on freshly fractured surfaces. Most of the crystals are polysynthetically twinned.

A chemical analysis by G. T. Holloway of corundum crystals from this locality gave the following result:—

	Per Cent.
Al_2O_3	97.9
SiO_2	1.4
CaO , FeO , and moisture (by difference)	.7
	100.00

* Bibl. Nos. 2, 8 and 11.

The analysis indicates corundum of exceptional purity. Unfortunately mining costs are high in this area and at the present prices paid for crystal corundum it has been found unpayable to work this deposit.

According to T. W. Gevers it is possible, if this locality were developed, that large tonnages of corundum may be proved but up to the present insufficient work has been done to estimate the quantities available.

Production of Corundum in Namaqualand.

(Information supplied by Statistical Office of Government
Mining Engineer, Johannesburg.)

<i>Year.</i>	<i>Quantity.</i>
1913	22·548 tons (2,000 lb.).
1914	12·432 „ „
1915	
1916	
1917	
1918	71·658 „ „
1919	53·527 „ „
1920	46·850 „ „
1921	
1922	
1923	25·633 „ „
1924	8·750 „ „
1925	12·750 „ „
1926	15·000 „ „
1927	6·000 „ „

There has been no recorded production since 1927.

2. *Natal.**

Corundum is found in Natal on the descent from Kranskop † to Middle Drift on the Tugela river. The deposits occur in serpentine bodies along the northern slopes of the Manyalete hill. The prevailing rocks of the region are hornblende schists, granulites and gneisses which have been invaded by a batholithic body of granite and riddled with numerous dykes and veins of pegmatite and aplite representing the final stages of acid injection.

Prior to this granitisation, the basement rocks, now represented by the hornblende schists, granulites, and gneisses, were invaded by ultrabasic intrusions, apparently sill-like in character, and generally conforming to, but in places transgressing across, the foliation of the basement rocks. These ultra-basic bodies are now more or less completely serpentinised and occur as a series of isoclinically folded masses on the northern slopes of Manyalete hill, Sitilo hill, Fort Yolland and elsewhere.

* Bibl. Nos. 2 and 3.

† This, the official Afrikaans spelling of Krantzkop or Krantz-kop, as formerly used in Natal publications.

These bodies of serpentine are also traversed by veins and dykes of pegmatite. It is in the latter that the corundum occurs and the view is expressed by du Toit that the mineral owes its origin to the desilicating action of the serpentine on the originally acid magma of the pegmatite intrusions. Quartz is absent in the resultant rock composed principally of acid plagioclase feldspar and corundum to which the name corundum aplite was given by du Toit. It is however practically identical with the oligoclase-corundum rock of California called "Plumasite" by Lawson.†

These corundum aplite intrusions are neither numerous nor large but a considerable amount of prospecting work was done on them during 1917 by E. S. Campbell. The results were disappointing. The bodies are seldom more than a few feet wide and are distinctly irregular in shape. Corundum tends to be concentrated in the central portions of these dykes and towards the apices of tongue-like offshoots, and it is generally associated with margarite. In places the rock is composed entirely of margarite and corundum and resembles very closely the "Marundites" of the north-eastern Transvaal described by Hall.*

It is doubtful whether these deposits will ever be found workable, firstly because of their generally small width and secondly because of the alteration of a considerable proportion of the corundum to soft, fibrous and minutely crystalline margarite and gibbsite.

3. *Piet Retief District, Transvaal.*†

On the farm Landsend No. 35, on the north bank of the Pongola river, about 12 miles below its confluence with the Pivaans river, corundum occurs as crystals and fragments lying on the surface of granite. Several thousand tons of eluvial material are said to be available. The locality is about 25 miles from the railhead at Gollé and the main road between Piet Retief and Gollé passes within a few miles of the farm. Most of the corundum contains a good deal of included ilmenite in minute grains and slivers and the presence of titanium in any form is regarded by some abrasive manufacturers as undesirable. Should the use of corundum for other than abrasive purposes be developed to any extent this deposit may be found worthy of exploitation.

The parent rock from which these crystals have been released by weathering is not exposed, but it is probably similar to that of the Kranskop occurrences in Natal in view of the fact that many of the crystals have a central core of corundum surrounded by margarite. Flakes of margarite are also found developed along the parting and twinning planes of some crystals.

4. *Swaziland.*§

Corundum in pyramidal and barrel-shaped crystals occurs in association with alluvial cassiterite at several localities in Swaziland. Up to the present however no workable deposit has been discovered.

† (Univ. of California, Bull. Geol. Dept. Vol. III, No. 8, pp. 219-229, 1904.)

* Bibl. No. 7.

† Bibl. No. 10. L. J. Krige and W. A. Humphrey.

§ Bibl. No. 8.

About half a mile west of Hlatikulu fragments of corundum crystals are found in gravel just below the surface of the ground.†

The fragments are angular and up to 4 inches in length, and show no signs of having been transported for any great distance from the parent rock from which they have been derived by weathering.

The ground on which the deposit occurs slopes westwards from the village of Hlatikulu, which lies near the top of a small plateau. All the outcrops seen in the vicinity are of Old Granite which extends for miles around. There are small patches of Pongola quartzite as well as diabase dykes and Karroo dolerite generally in the form of sheets. Here and there small inclusions of basic and ultra-basic rocks are found in the granite and although not observed in this locality may be present. From the analogy of the Kranskop, Natal, and the Transvaal occurrences it seems possible that occurrences of primary corundum-bearing rocks may occur within these included masses of basic and ultra-basic rocks where they have been invaded by pegmatites associated with the old granite.

5. *Minor Occurrences.*

The following are a few minor occurrences of corundum which are mainly of academic interest and of no economic importance as sources of supply of the mineral for industrial purposes.

*Lydenburg District.**—A corundum-sillimanite rock occurs on the farm Thorncliffe, about 22 miles west of Lydenburg. It forms a layer up to 10 inches wide encased in anorthosite in an alternating succession of norite, chromite and anorthosite of the Bushveld complex.

It is believed to have originated as an aluminous sediment caught up in the norite magma and subjected to intense metamorphism accompanied by interaction with magmatic material.

Barberton District.‡—Corundum occurs in association with tourmaline in a large xenolith of highly metamorphosed quartzite in the rocks of the Jamestown series west of the old main road leading up Bullion hill to Salvation valley.

Seta Alluvial Diamond Mine.—Limpopo valley. Rounded pebbles of green and of pink corundum up to 1 inch in diameter are found in the alluvial diamondiferous gravel on the farm Riedel No. 618, about 40 miles west of Messina along the Limpopo valley.

Waterworn pebbles of corundum are also found, though comparatively rarely, in the diamondiferous gravels of the Lichtenburg district and the Vaal river valley.

South West Africa.—Small occurrences of corundum have been reported from the Omaruru and Warmbad districts in South West Africa.

In the latter locality crystals up to 3 inches in length and $\frac{1}{2}$ inch in diameter occur in eluvial deposits derived from lenses of corundum-bearing biotite schist in old granite and gneiss.

† Verbal communication from L. J. Krige, Geological Survey.

* Bibl. No. 12.

‡ Bibl. No. 13.

CHAPTER VI.

PRODUCTION AND MARKETING.

1. *General.*

With the exception of small quantities from Namaqualand, the Transvaal has supplied the bulk of the corundum produced and exported from South Africa since 1912, when the first shipments were made. During the last seven years the entire output has come from the Transvaal.

In view of this fact, all further matters dealt with in this publication, e.g. types of corundum produced, methods of mining and recovery, marketing, grading, etc., will refer particularly to the Transvaal, unless otherwise stated.

In the table below the quantity and value* of all corundum produced for export from 1912 up to the present time is given.

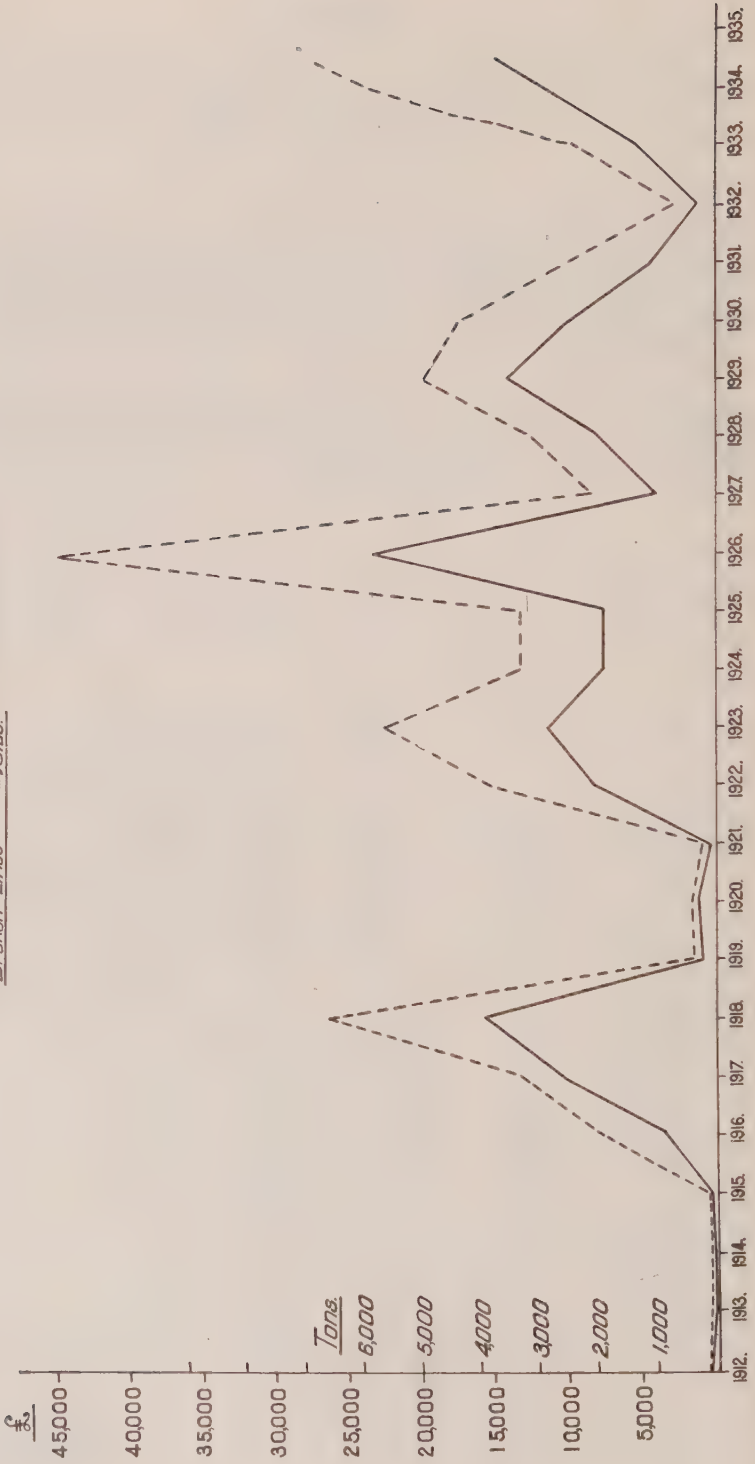
SALES AND SHIPMENTS OF CORUNDUM: UNION OF SOUTH AFRICA.

Year....	Quantity.	Value	Remarks.
	Tons (2,000 lb.).	£	
1912.....	111	659	All from Transvaal.
1913.....	13	128	All from Namaqualand, C.P.
1914.....	12	144	All from Namaqualand, C.P.
1915.....	68	480	1 ton, value £10, from Natal.
1916.....	755	7,762	All from Transvaal.
1917.....	2,629	13,038	All from Transvaal.
1918.....	3,876	26,260	45 tons, value £526, from Namaqualand.
1919.....	179	1,486	48 tons, value £568, from Namaqualand.
1920.....	261	1,446	15 tons, value £150, from Namaqualand.
1921.....	123	770	All from Transvaal.
1922.....	2,024	15,492	0·37 tons, value £5, from Namaqualand.
1923.....	2,815	22,543	12 tons, value £86, from Namaqualand.
1924.....	1,868	13,284	All from Transvaal.
1925.....	1,832	13,229	All from Transvaal.
1926.....	5,996	44,871	All from Transvaal.
1927.....	1,064	8,473	All from Transvaal.
1928.....	2,019	12,696	All from Transvaal.
1929.....	3,607	19,879	All from Transvaal.
1930.....	2,548	17,635	All from Transvaal.
1931.....	1,129	10,357	All from Transvaal.
1932.....	362	2,621	All from Transvaal.
1933.....	1,304	9,531	All from Transvaal.
1934.....	3,202	23,844	All from Transvaal.
1935.....	4,775	36,552	All from Transvaal.
TOTAL.....	42,572	303,180	

* In the case of Transvaal corundum, the values are f.o.r. nearest railway station.

Graphs illustrating Sales and Shipments of Corundum.

Unbroken Lines — Quantity in Tons (2000 lbs.)
Broken Lines — Value.



From these statistics it can be seen that the production of corundum in the Union since its inception in 1912 has been subject to many fluctuations. There were peak periods of production in the years 1918, 1923, 1926 and 1929. During 1932 the worst slump was experienced since that of the post-war years 1919-21. Fortunately, however, this did not last as long as the previous one but nevertheless in that year there was practically no market for corundum. Many diggers abandoned their workings and production was virtually at a standstill. Consequently, in the latter part of 1933, when the demand began to improve once more, exporters found some difficulty in obtaining sufficient supplies to meet their contracts. In 1934 the position had improved considerably and an average export rate of approximately 200 tons per month could be maintained. The continued demand and slightly increased prices paid to the diggers led to the reopening of many abandoned workings and the discovery of new deposits. Moreover, owing to the severe drought of the past two seasons, many farmers turned to corundum digging as a means of earning a livelihood. It has been estimated that during the first half of 1935 between 300 and 400 Europeans and about 4,000 natives were engaged in digging corundum. Production rose to approximately 500 tons per month. The normal demand for export, however, did not increase to the same extent and consequently there has been an accumulation of unsold material. Whether the demand will increase in the near future to absorb the present surplus depends entirely on the trend of world economic conditions and especially on activity in the heavy engineering industries in the United States of America. As far as can be judged the prospects in this direction are good.

On the other hand if the coming summer turns out to be a good rainy season many of the farmer-diggers will return to their farming operations and a somewhat lower rate of production can be expected. In this way a more even relation between production and export may again be restored.

Attention to the corundum deposits in the northern Transvaal was first drawn by the occurrences of boulder and eluvial corundum in the Zoutpansberg district and in north-eastern area around Mica Siding. In the early years of the industry attention was paid mainly to the superficial outcrops of boulder corundum and eluvial deposits, situated within easy reach of the Pietersburg-Louis Trichardt and the Zoekmekaar-Komatipoort railway.

During the period of high production 1916-1918, culminating in the output of about 4,000 tons during 1918, these were still the only types of deposits exploited, and at that time the country within a radius of not more than 20 miles from Bandalier Kop station and the eastern Transvaal area around Mica siding were the most important producing areas.

As the more productive deposits within easy reach of the railway became depleted prospecting was carried further afield in a westerly direction towards the Blaauwberg, eastwards towards the Shingwedzi river and more recently northwards beyond the Zoutpansberg. By 1926 the Blaauwberg region had become the most important, but a small output was nevertheless maintained from the Bandalier Kop and eastern Transvaal areas.

At present corundum is being produced from deposits over the whole area (see map Fig. 2), but the greater portion of the output still comes from the area between the Blaauwberg and the Sand river.

Complete statistical records of the production of corundum from the various deposits or farms have not been kept. The only returns that have to be made to the Department of Mines are of the quantity and value of corundum sold and shipped and this is usually done by the buyers and exporters. Actual production records of individual farms or deposits are only available in the private records of some of the corundum buyers and land-owning companies.

There is no doubt that the production of corundum has been of considerable benefit to these districts in which it has been exploited as it has enabled several hundred European inhabitants to make a living or to augment their incomes by digging corundum in addition to the normal occupation of stock farming which is the principal agricultural pursuit in those parts of the Transvaal.

2. *Types of Corundum Produced.*

The different forms in which corundum is recovered and exported are determined by its mode of occurrence and the methods employed for its recovery.

In the Government Export and Grading Regulations (see Appendix No. 2) four types of corundum which may be exported are recognised. They are boulder corundum, crystal corundum, corundum concentrate, and grain corundum.

Boulder Corundum.—This term is applied to any corundum-bearing rock usually very hard and containing a high percentage of corundum which has not undergone any form of mechanical treatment except breaking to convenient size for handling.

On account of the high corundum content (frequently up to 80 per cent.) of many of the outcrops of boulder corundum, this type of material was the first to attract commercial attention. The boulders were simply broken by blasting to pieces, small enough for handling, and then railed and exported as such. During the Great War period, when abrasives of any kind were at a premium, large quantities of this material were exported. This type of corundum has, however, gone out of favour to a large extent owing to the difficulties experienced, by manufacturers of abrasive grains, in crushing and cleaning the material. In most varieties of "boulder" corundum the corundum is so intimately intergrown with the other constituent materials of the rock that the cost of producing clean corundum grain was found to be prohibitive. At present there is only a very limited demand for boulder corundum. Small quantities are, however, still exported from time to time.

Since 1931 the sales and shipments of boulder corundum were as follows:—

<i>Year.</i>	<i>Quantity.</i>
1932	79·520 tons (2,000 lb.).
1933	60·480 " "
1934	145·145 " "

Boulder corundum for export is usually sold on the basis of minimum total alumina content of 65 per cent. The material exported, however, usually contains well over 70 per cent. alumina. The value of such material varies according to the quality (i.e. corundum content) from £2. 10s. to £3. 10s. per long ton free on rail, northern Transvaal.

It is believed that some of the boulder corundum exported from South Africa has been used for the preparation of grain merely by crushing and screening to the required sizes, and that the material so obtained was found useful for mixing with other types of grain (e.g. artificial) in the manufacture of certain abrasive products. Although this type of material may have been found useful for certain purposes it should not be confused with grain corundum and concentrate, prepared in South Africa, which if exported would have to comply with and be graded in accordance with the provisions of the Export and Grading Regulations. Boulder corundum of the type that has been exported compares favourably with emery as regards corundum content. The percentage of total alumina in emery varies from 10 to 75 per cent., an average content for the material used for abrasive purposes being 64 per cent. The percentage of corundum in emery, however, seldom reaches 50.*

It has been suggested that boulder corundum if crushed and roughly concentrated so as to provide a product containing at least 80 per cent. total alumina and then graded into the generally accepted sizes of grain, used by grinding-wheel manufacturers, should provide a readily marketable product. The opinion has been expressed by a well-known mineral dealer in London, who has been interested in Naxos and Turkish emery for many years, that manufacturers who still make grinding wheels with emery would prefer to use crushed and graded boulder corundum prepared as described above if it could be obtained at the same price as grain emery.

A trial quantity of this material is at present being prepared at the Minerals Research Laboratory, Johannesburg, and will be distributed to abrasive wheel manufacturers for testing. If this material is found suitable there is no reason why an appreciable export trade in this type of corundum should not be built up.

Crystal Corundum.—In this category is included all corundum in the form of loose crystals and fragments above $\frac{1}{8}$ inch in size, which have been separated from the rock or earth in which it is found and from which all adhering impurities have been removed as far as possible. A distinction is sometimes made between—

- (i) "eluvial" crystal derived from eluvial deposits, and
- (ii) "mine" crystal derived from "reef" or primary deposits.

The export trade in South African corundum has largely been built up on crystal corundum and at the present time, except for the small quantities of boulder corundum already referred to, it is the only type of corundum exported.

* Publication of the Imperial Institute, London, on "Abrasives," 1929, p. 21.

There is an established market for this product in the United States of America and practically the whole output is exported into that country as crude raw material for the preparation of abrasive grain used in the manufacture of grinding wheels and for other purposes (see Chapter VIII).

Corundum Concentrate and Grain Corundum.—Corundum in the form of “concentrate” or “grain” is the product obtained by the mechanical crushing of boulder corundum or any corundum-bearing rock of the primary deposits to at least minus $\frac{1}{8}$ inch, and the subsequent elimination of gangue minerals. When exported as concentrate the product is not screened and separated into the various size grades but when it is graded into the standard sizes it is designated “grain corundum”. Corundum concentrate is a partly prepared abrasive raw material which requires further treatment in the form of screening and crushing of the coarser fractions before it can be regarded as grain corundum suitable for the manufacture of abrasive wheels. Grain corundum on the other hand is the finished product ready for use in the manufacture of grinding wheels of the particular degree of fineness or coarseness that may be required. Grain corundum was produced by the Transvaal Corundum Company during the period 1921-1923 and the following quantities were exported:—

<i>Year.</i>	<i>Quantity.</i>
1921	3·750 tons (2,000 lb.).
1922	155·000 ,, ,,
1923	449·900 ,, ,,

The product was considered excellent by abrasive wheel manufacturers and there is no doubt that the undertaking would have been successful if a regular supply could have been kept up. Several difficulties, some technical and other financial, were, however, encountered and prevented the maintenance of a regular output. Eventually operations were suspended and the company liquidated in 1928.

Corundum concentrate was produced by the South African Corundum Company at Bandalier Kop during the period 1930-1931, and the following quantities were exported:—

<i>Year.</i>	<i>Quantity.</i>
1930	266·170 tons (2,000 lb.).
1931	344·950 ,, ,,
1932	39·200 ,, ,,
1933	37·408 ,, ,,
1934	1·120 ,, ,,

In this case, also, satisfactory reports about the abrasive qualities of the product were received from consumers in the U.S.A., England and Germany. Unfortunately it came on the market during the period of falling demand and the company was forced to suspend operations towards the end of 1931. All subsequent deliveries were made from their accumulated stocks.

There is evidence at present, however, of a good deal of interest, on the part of abrasive wheel manufacturers in England, in these

types of material and it is likely that the production and export of corundum concentrate and grain corundum will be resumed in the near future.

3. Grading.

Although the different forms in which corundum is exported had been established in practice, no uniform or generally recognised system of classification or grading was in force before 1931. Contracts were made largely on samples. Some of the established buyers and exporters had evolved their own respective systems of grading and classification which were recognised and accepted by the buyers or consumers overseas.

No definite criteria, however, were used to define the grades and sizes. The grading and classification was consequently crude and often inaccurate. Occasional check analysis of the alumina (Al_2O_3) content were made, but the quality of the corundum was judged largely on sight. In this connection it should, however, be stated that to the experienced eye the behaviour of corundum when broken and the appearance of a freshly fractured surface conveys a great deal. Corundum of good abrasive quality has a bright glassy to adamantine lustre and breaks with an uneven splintery surface. Corundum of which the lustre is dull on a freshly fractured surface, or that which breaks easily with smooth even surfaces as when poly-synthetic twinning and parting planes are well developed, is not of good quality for abrasive purposes.

The features by which the quality of corundum can be judged by sight can be briefly summarised as follows:—

	<i>Favourable.</i>	<i>Unfavourable.</i>
Lustre	Bright glassy to adamantine.	Dull to pearly.
Fracture... ..	Uneven or splintery.	Smooth or even.
Cleavage or parting	Absent.	Well developed.
Inclusions	Absent or as few as possible.	Presence of mica, rutile, ilmenite, etc.

Unfortunately accurate quantitative determinations of these features cannot readily be made, and consequently they cannot be used as criteria for any definite system of grading.

During the periods when there was a strong demand for corundum this lack of definite grades presented no difficulties and as can be seen from the production and export figures (page 29), large quantities of corundum were sold especially during the Great War period 1916-18 and again subsequently in 1922-1930 with minor slumps in between. During the slump periods, especially the one of 1927, disputes arose between the producers and buyers and exporters in South Africa and between the latter and the overseas buyers and manufacturers of abrasive products as a result of this lack of a definite system of grading and standards of quality.

The matter was investigated and after the views of the overseas consumers and the local producers and exporters had been obtained the Government on the recommendation of the Department of Mines

decided to proclaim corundum as a mineral subject to the provisions of the Restricted Minerals Export Act, No. 35 of 1927. In terms of the above-mentioned Act of Parliament, regulations governing the grading and export of corundum were drawn up and promulgated in February, 1931. (Government Notice No. 288, in the *Government Gazette* of 13th February, 1931. The regulations are published in extenso in Appendix No. 2.)

In the grading regulations the total alumina (Al_2O_3) content is taken as a measure of quality. In view of the fact that the principal industrial use of corundum, namely as an abrasive, depends primarily on a particular physical property, its hardness, some physical test of abrasive efficiency would have been preferable. The lack of an entirely satisfactory and reliable standard method of measuring abrasive efficiency made it necessary to adopt a chemical standard of quality. Total alumina content was regarded as the most suitable for this purpose. Even before the Government Grading Regulations were enforced overseas buyers used the total alumina content as a check in determining the grade of shipments of corundum.

In practice this method has been found satisfactory for, at any rate as far as the material from the Transvaal is concerned, corundum with a high total alumina content possesses good abrasive qualities. The presence of any impurities, likely to affect the abrasive efficiency of the corundum, whether in the form of inclusions or alteration products of the corundum itself, is reflected in a lower total alumina content.

In addition to laying down the classification and standards of grading, the Export and Grading Regulations make provision among other things for (1) the examination, sampling, and assaying of consignments of corundum for export, (2) the conditions under which corundum should be stored, sorted and graded, (3) the type of containers to be used where necessary, and the marking of such containers, (4) the issuing of export certificates.

The administration of the Restricted Minerals Export Act, No. 35 of 1927, is vested in the Department of Mines, and that of the Corundum Export and Grading Regulations carried out by a chief grader and two deputy-graders.

No consignment of corundum may be exported unless it conforms to the provisions of the regulations and an export certificate for it has been issued by one of the authorised grading officials.

Grading of Boulder Corundum.—The grade or quality of boulder corundum is indicated by the average total alumina (Al_2O_3) content of the rock. No specified minimum percentage is laid down in the regulations and this is usually a matter for agreement between buyer and seller. In practice a minimum of 65 per cent. Al_2O_3 is generally insisted upon.

Grading of Crystal Corundum.—Crystal corundum is graded according to total alumina content and size as follows:—

Alumina Content.

- A. Containing not less than 92 per cent. Al_2O_3 .
- B. Containing less than 92 per cent. but *not* less than 90 per cent. Al_2O_3 .
- C. Containing less than 90 per cent. but *not* less than 85 per cent. Al_2O_3 .
- D. Containing less than 85 per cent. Al_2O_3 .

Size.

1. Coarse: Oversize of $\frac{1}{2}$ inch diameter round hole screen.
2. Medium:
Undersize of $\frac{1}{2}$ inch diameter round hole screen.
Oversize of $\frac{1}{4}$ inch diameter round hole screen.
3. Fine:
Undersize of $\frac{1}{4}$ inch diameter round hole screen.
Oversize of $\frac{1}{8}$ inch diameter round hole screen.
4. Mixed: All oversize of $\frac{1}{8}$ inch diameter round hole screen.

According to the above-mentioned standards of size and alumina content, the following grades can be made up and are designated by Grade Symbols as follows:—

<i>Grade Symbol.</i>	<i>Alumina Content.</i>	<i>Size.</i>
A1	Over 92 % Al_2O_3	Coarse.
A2	" "	Medium.
A3	" "	Fine.
AM... ..	" "	Mixed.
B1	Under 92 % but over 90 % Al_2O_3	Coarse.
B2	" " " "	Medium.
B3	" " " "	Fine.
BM... ..	" " " "	Mixed.
C1	Under 90 % but over 85 % Al_2O_3	Coarse.
C2	" " " "	Medium.
C3	" " " "	Fine.
CM... ..	" " " "	Mixed.
D1	Under 85 % Al_2O_3	Coarse.
D2	" " " "	Medium.
D3	" " " "	Fine.
DM... ..	" " " "	Mixed.

At present the requirements of American consumers, and the nature of the crystal corundum exported are such that in actual practice only three grades are exported. These are A1, A2 and B3. In other words the minimum alumina-content of the coarse and medium sizes is 92 per cent., while for the fine size of crystal corundum a minimum of 90 per cent. alumina is accepted. In this connection the average alumina-content of actual shipments of the different grades of crystal corundum exported during the past two years is of particular interest*

In the year 1933, 841·8 long tons of the A grades (A1 and A2) were exported and the average alumina content was 95·15 per cent. For the year 1934 the figures are 1,979·7 long tons and 94·96 per

* From information supplied by the Chief Grader.

cent. Al_2O_3 respectively. This gives a total of 2,821·5 tons and an average alumina content of 95·02 per cent. over the two years 1933 and 1934. For the same period the figures for the B grades (principally B3) exported are as follows:—

	1933	...	156·7	long tons.	94·6 %	Al_2O_3
	1934	...	602·3	„ „	90·82 %	„
Total 1933 and 1934	...	759·0	„ „	91·62 %	„	„

These figures show that the minimum alumina content for the above-mentioned grades has been exceeded in each case.

During the past two years only 119·4 long tons of C grade crystal with an average of 87 per cent. Al_2O_3 have been exported. This represents occasional shipments or portions of shipments, the grade of which has fallen below the required minimum and which have consequently been degraded into the “C” class.

While it is theoretically possible to obtain fine crystal corundum (i.e. crystals and fragments which fall between the $\frac{1}{4}$ -inch and $\frac{1}{8}$ -inch screens) sufficiently clean to have a total alumina-content of 92 per cent. and over, the average run of crystal corundum of this size falls below 92 per cent. Al_2O_3 . The reason for this is probably that owing to the greater exposed surface area of smaller fragments, the possibilities of chemical alteration and of admixture with adhering impurities is greater than with large crystals. It has been the experience of manufacturers of corundum “grain” that the small crystals and fragments invariably produce higher percentage of loss as fine dust or “flour” than do the larger crystals, when crushed. This fact is naturally reflected in the price and the fine sizes of crystal are worth relatively less than the coarser sizes even if of the same grade.

Prices have fluctuated a good deal since corundum was first produced in the northern Transvaal, and have ranged from about £3. 10s. to £10 per ton. Occasionally higher prices have been paid for small quantities of specially selected crystals. At present while some buyers may offer slightly more than others the average range of prices, free on rail northern Transvaal, for the three grades exported are as follows:—

£8-£9	for A1	per short ton.
£7-£8	for A2	„ „
£5-£6	for B3	„ „

Crystal corundum for export is usually re-sorted and re-graded at the various buyers' depots before it is finally bagged for export. The larger producers generally sell direct to the exporters, but throughout the district in which corundum is produced it is regarded as a trading commodity and many of the smaller producers generally sell their corundum to one of the outside storekeepers who may export direct or act as buying agent for some other exporter. (The names of buyers and exporters of corundum are given in Appendix No. 3.) At present the bulk of the export business in corundum is confined to two channels and Pietersburg, Louis Trichardt and Mara are the principal stations from which corundum is railed for export.

Grading of Corundum Concentrate.—In framing the Export and Grading Regulations the term "Corundum Concentrate" was included in the classification of corundum for export in order to make provision for the product prepared by the S.A. Corundum Co., at Bantolier Kop during the period 1930-1931.

Corundum concentrate is graded according to alumina-content, as in the case of crystal corundum, but not according to size. In order to get a payable percentage recovery and a concentrate, going over 92 per cent. alumina, from the various types of boulder corundum used as the raw material, it was found necessary to crush the rock so that all of it could pass through an 8 to the linear inch mesh screen. The size of the grains in the concentrate therefore ranged from $\frac{1}{8}$ -inch downwards.

The price obtained for this material during 1931 was in the neighbourhood of £15 per long ton c.i.f. London.

Grading of Grain Corundum.—This type of corundum is graded according to alumina-content as in the case of crystal corundum and is graded into the various accepted commercial sizes of grain.

The sizes in general use are as given below:—6, 8, 10, 12, 14, 16, 20, 24, 30, 36, 40, 50, 60, 70, 80, 90, 100, 120, 150, 180, 220, these being the mesh of the screen through which the grain will just pass. The particles finer than 220 are known as "flour" of the "F" grades and are further graded by allowing the material to settle in water over varying periods of time. In this way the 28-, 32-, 40-, 50-, and 60-minute "F" grades are obtained.

4. Ownership.

The legal aspects of the ownership, right of mining and disposal of corundum in the Transvaal can be briefly summarised as follows:—*

1. Corundum for the purposes of the mineral laws of the Union of South Africa is a base metal.
2. On Crown land the ownership and the right of mining for and disposing of base metals is vested in the Government, and on private land in the owner of the soil, unless the mineral rights have been severed from the ownership of the soil.
3. On ordinary private land held with full mineral rights the owner may win and dispose of corundum at will, subject to the Mines and Works Act and Regulations and the Restricted Minerals Export Act, No. 35 of 1927.
4. On private land, where the mineral rights have been severed, the right of mining and disposing of corundum rests in the person in whose favour the mineral rights are registered.

* The writer is indebted to Mr. A. Eales, Department of Mines, Pretoria, for this information.

5. On privately owned land, the mineral rights whereof are registered in favour of the Crown, the right to win corundum may be obtained by the surface owner under the Reserved Minerals Development Act, No. 55, 1926 which confers on him the exclusive right of searching for minerals on such land.
6. On proclaimed Crown land which is open to the peggining of base-metal claims, any person duly licensed thereto by the Mining Commissioner may peg up to a maximum of 100 base-metal claims, each 150 feet by 400 feet in extent and may win and dispose of corundum under such licence.
7. On native locations situate upon Crown land, persons who wish to prospect for and mine corundum are required to obtain a Crown Lands prospecting permit from the Mining Commissioner and a special form of permission from the Department of Native Affairs.

Tributing Agreements and Royalties.—In some cases the mining of corundum is done by the owners of the land themselves, but more usually by European diggers under tributing agreements with the owners.

Company Farms.—In the northern Transvaal a large number of farms and blocks of adjoining farms are owned with full mineral rights by land companies such as the Transvaal Consolidated Land Co., African and European Investment Co., S.A. Townships Mining & Finance Co., and others.

The land companies which are members of the Transvaal Land owners' Association have recently adopted a common tributing agreement under which the exclusive right to prospect for and win corundum is granted.

Tributing agreements are now very rarely entered into between the companies and individual diggers, but more usually between the former and a responsible local buyer and exporter of corundum, who in turn relegates his authority to exploit corundum to individual diggers and also exercises a certain amount of supervision over the mining, recovery and preparation of the corundum for the market. Under this agreement, in consideration of the rights granted to him the tributor undertakes to pay the owner a royalty of 12½ per cent on the gross selling price of all corundum won, with a minimum payment of 15s. per short ton on "crystal corundum" and 5s. per short ton on "boulder corundum", and subject to a minimum overall royalty of £5 per month.

Private Farms.—Where the mineral rights of farms are vested in individual private owners who are not members of the Transvaal Land Owners' Association, many different forms of tributing agreements are in existence. Some of them include the payment of different fixed amounts as royalties and others the division of the corundum won between owner and digger on a proportional basis varying from one-quarter to one-half of the output to the owner.

In a few instances private owners allow their native squatters to collect corundum from eluvial deposits and buy the corundum from

collected, usually by native women, at a prescribed rate depending upon the ruling prices paid for corundum in the district. The amount of corundum recovered in this way is a very small fraction of the total output.

Native Locations.—In the case of native locations, anybody who has obtained the necessary permission to win corundum is called upon to pay a minimum royalty of 10s. per short ton on crystal corundum and 2s. 6d. per short ton on boulder corundum.

CHAPTER VII.

MINING AND RECOVERY.

1. *General.*

The methods of mining and recovery of corundum in the northern Transvaal and the results achieved must be considered in the light of local conditions such as the mode of occurrence, distribution of the deposits, the value of and the demand for the various types of corundum produced.

Some of these conditions have already been described but they may be briefly summarized as follows:—

- (1) The deposits are generally comparatively small, irregular in form, variable in corundum content, and occur sporadically over a very large area.
- (2) The country is generally flat, soil- and bush-covered, and water is relatively scarce.
- (3) The only type of corundum for which there has been a fairly constant market, although the demand has fluctuated considerably, is crystal corundum.
- (4) The output from the individual workings is small and varies from less than a ton up to about 30 tons per month.
- (5) On the whole the average profit to the producer for the effort and expense involved is relatively small.

For these reasons large-scale mining and recovery operations have never been attempted. The production of corundum has always been carried on by a large number of diggers working intermittently on a small scale and in most cases with little or no capital. In some cases the diggers are financed by the buyers or exporters against the forward delivery of corundum, but at best it is a hand-to-mouth existence. There have, of course, been instances where some highly productive deposits have yielded handsome returns to the diggers and owners of the ground but these are exceptions rather than the rule.

Mining.—In general the corundum is mined and recovered from shallow open workings, few of which penetrate to depths greater than 10 feet from the surface. In some of the deeper workings on narrow vein-like deposits a certain amount of underground mining has been done.

The work is done by European diggers with gangs of native labourers and in general it can be said that the methods employed are somewhat primitive. At most of the eluvial and many of the reef workings no mining appliances other than picks and shovels are used. Where the rock is hard a certain amount of hand drilling and blasting is done.

At some of the deeper workings, such as at Blinkwater, Borkum and Westphalia, where depths of close to 100 ft. have been reached the broken rock is hoisted by means of hand-operated or power-driven cranes. In other cases it is shovelled to the surface from one platform to another.

Recovery.—At most of the workings, except those where boulders of corundum is mined for sale as such, the methods employed have as their object the recovery of as large a proportion as possible of the available corundum in the form of crystal corundum. As with the mining the recovery methods employed are likewise crude and often wasteful. Most of the operations are performed by manual labour—sometimes implemented by simple and often home-made mechanical devices.

2. *Eluvial Corundum.*

In the eluvial deposits the corundum is clean and generally free from adhering impurities and the problem of recovery is merely to separate the corundum from the accompanying earth and rubbish. The methods used at the various workings differ in detail and depend on the nature of the ground whether clay, sand, gravel or surface limestone and the average size of corundum and other rock fragments in the deposit. After the ground has been excavated the corundum is recovered by a combination of all or some of the following processes:—

- (1) Coarse screening over 1 to $\frac{1}{2}$ -inch mesh inclined, stationary or horizontal, rocking screens.
- (2) Fine screening over $\frac{1}{8}$ -inch mesh screen.
- (3) Washing of screened portion which passes through the coarse but stays on the fine screen (minus 1 inch plus $\frac{1}{8}$ inch) in rotary pan washer similar to that used on the alluvial diamond fields.
- (4) Hand-gravitating or -jigging on small circular hand sieves.

The large crystals and fragments are usually recognised by the native workers while excavating or screening the earth and picked out and washed separately.

The smaller fragments recovered after repeated hand-gravitating until a clean product is obtained are then sun-dried and graded in three sizes as laid down in the Export and Grading Regulations. In most cases the final grading is done at the various buyers' depots.

In view of the fact that corundum occurs in the free state in the eluvial deposits and on account of its high specific gravity (3.9), the recovery by the methods described is fairly good. A great deal, of

course, depends upon the experience of the digger and the amount of supervision exercised over the native labourers. In general, however, it may be stated that there is little wastage in the recovery of the coarser crystal corundum sizes from eluvial deposits.

All the fine corundum, i.e. that which passes through the $\frac{1}{8}$ -inch screen is lost and no effort is made to recover it because there is at present no market for this product. This aspect of the matter will be referred to again subsequently.

3. " Reef " Corundum.

The mining of the " reef " or primary deposits has up to the present mostly been done where the corundum-bearing rock has been softened by the weathering of the felspar, as in some of the plumasites, or where the rock is naturally friable, as in some of the micaceous corundum-bearing gneisses. In a few instances where highly payable quantities of corundum have been found, hard " reef " deposits have been mined by blasting, but many of the " reef " workings have been abandoned at 10 to 20 feet from the surface with payable quantities of corundum still showing on the reef, on account of the rock becoming too hard. In most of the plumasite and other reef deposits the larger corundum crystals break away with but little of the adhering gangue minerals when the rock is soft enough to be excavated by pick and shovel. This is also the case even when the rock is so hard as to require blasting and further breaking by hand hammer. The larger crystals and fragments can therefore be picked out by hand but the rest of the rock must be broken down still further by hand-cobbing. At some workings the proportion of crystal corundum recovered by these methods is less than 50 per cent. of the total corundum-content of the rock. The crude lumps and crystals thus obtained are then further treated to remove the adhering gangue minerals by one or more of the following methods:—

- (1) Further hand-cobbing.
- (2) Hand-stamping. The impure corundum fragments are placed in a steel drum which has been sunk into the ground and is then " stamped " by hand for about half an hour or more with a piece of drill steel, crowbar, or any other available steel rod. The object of this process which seems to combine maximum physical effort with minimum results is not to pulverise the corundum but to cause a rubbing action by which adhering minerals are removed. Apart from the slowness and inefficiency of the method a certain amount of breaking does take place and the minus $\frac{1}{8}$ -inch fragments thus produced are wasted.
- (3) Barrel-cleaning. This is a simple application of the tubemill principle. A cylindrical metal drum is partly filled with the crude uncleaned corundum as obtained by hand-cobbing, hand-sorting or screening of the reef rock as mined, and is then rotated on a horizontal axis. Some larger fragments of boulder corundum are sometimes inserted to assist in the grinding action and in this way the adhering felspar, mica, etc., is knocked off and ground to dust while most of the corundum remains intact.

This method has been found quite effective and is the most commonly used method of cleaning corundum recovered from reef deposits.

There are two modifications of this process.

- (a) A 44-gallon steel petrol drum is fitted with four 3-inch rib-plates rivetted so as to project radially from the inner walls of the drum. The drum is filled to about a quarter or one-third of its capacity and rotated on a horizontally mounted axis, inserted through the circular end plates of the drum. Handles are fitted to the ends of the axle and the drum is rotated by hand at about 60 revolutions per minute.

Each charge remains in the drum for about 10 to 15 minutes and is then hand-jigged in water or sieved dry to remove the dust and fragments of gangue minerals.

The radial rib-plates serve to lift and then to drop the fragments as the drum is rotated thereby increasing the pulverising action on the softer gangue minerals.

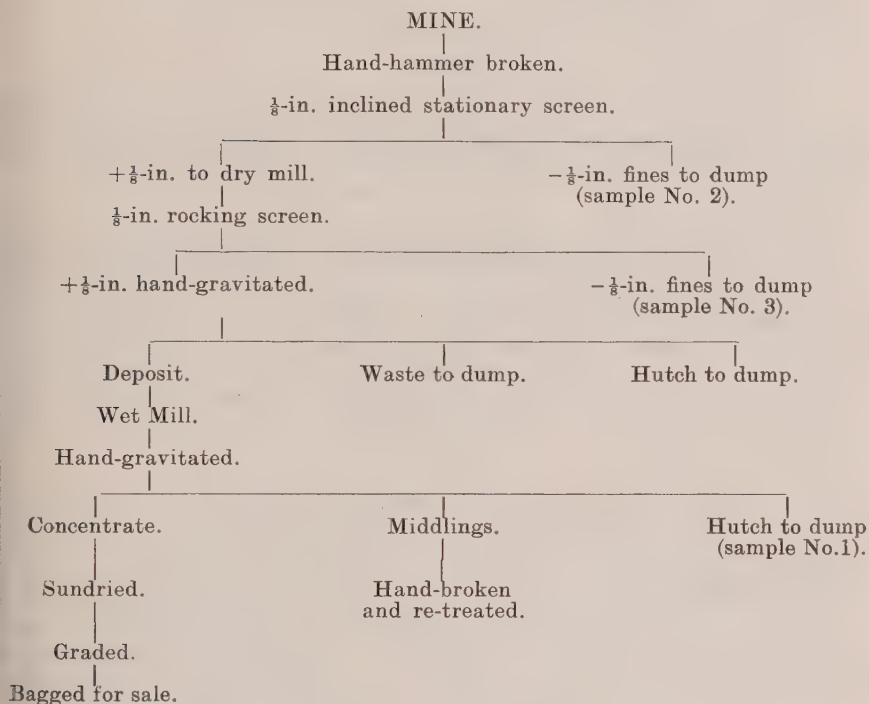
- (b) A minor modification of this method is to use a somewhat larger drum which is similarly fitted with a horizontal axis—the ends of which are hitched to the drag-chain of a span of four or six oxen. The drum is then rotated by the oxen pulling the drum, like a roller, over the veld until the corundum on its side is sufficiently clean.

4. Beater Mill. This type of cleaner is in use at Blinkwater and at some other deposits where the rock is of the friable micaceous gneissic variety. The broken rock as mined is first screened over a $\frac{1}{8}$ inch screen to remove the fines, then placed in a 10 ft. by 18 in. steel pipe through which a shaft with numerous propeller or "beater" blades is fitted. The shaft is then rotated at a high speed by a belt driven from an old farm tractor engine.

This may be operated either as a dry or wet process and has the same effect as the other method of barrel cleaning but it is more drastic and quicker in operation and larger quantities can be treated per day than by the other methods described above.

The scheme of recovery operations at Gerber's working on van Rooyen's portion of Blinkwater, which is the biggest and most consistent producer in the northern Transvaal is given below. The average output from this working is in the neighbourhood of one ton of marketable crystal corundum per working day.

*Sketch of Flow-sheet at Blinkwater for the Recovery of
"Crystal" Corundum.*



Samples from the dumps of waste products discarded at various stages of the operations were taken by Prof. Stanley and examined at the Metallurgical Research Laboratory, Johannesburg.

The results are as follows:—

Sample No. 1	contains	41 %	corundum.
„ No. 2	„	8 %	„
„ No. 3	„	12 %	„

These figures indicate that in addition to the "crystal corundum" recovered a large proportion of the corundum-content of the reef deposits remains in the minus $\frac{1}{8}$ -inch fines, and is at present not recovered. This is also true of some of the eluvial deposits.

If a market could be found for this fine-grained corundum and a sufficient demand arise to justify the adoption of modern milling methods the material at present discarded as waste would constitute a readily available and already partly prepared raw material for the production of a marketable concentrate.

4. Boulder Corundum.

Boulder corundum where it is mined in order to be sold and exported, as such, requires no further treatment other than breaking up into fragments small enough to be handled. Whether it is found as surface boulders or encountered in the reef workings it is simply

hand-drilled and then broken by blasting and further broken down by means of heavy sledge hammers to the size of anything from about 1 cub. foot downwards.

5. *Grain Corundum and Concentrate.*

The foregoing remarks refer particularly to the production of boulder corundum and crystal corundum recovered from eluvial deposits and such reef deposits from which crystal corundum can be recovered by the primitive methods in use.

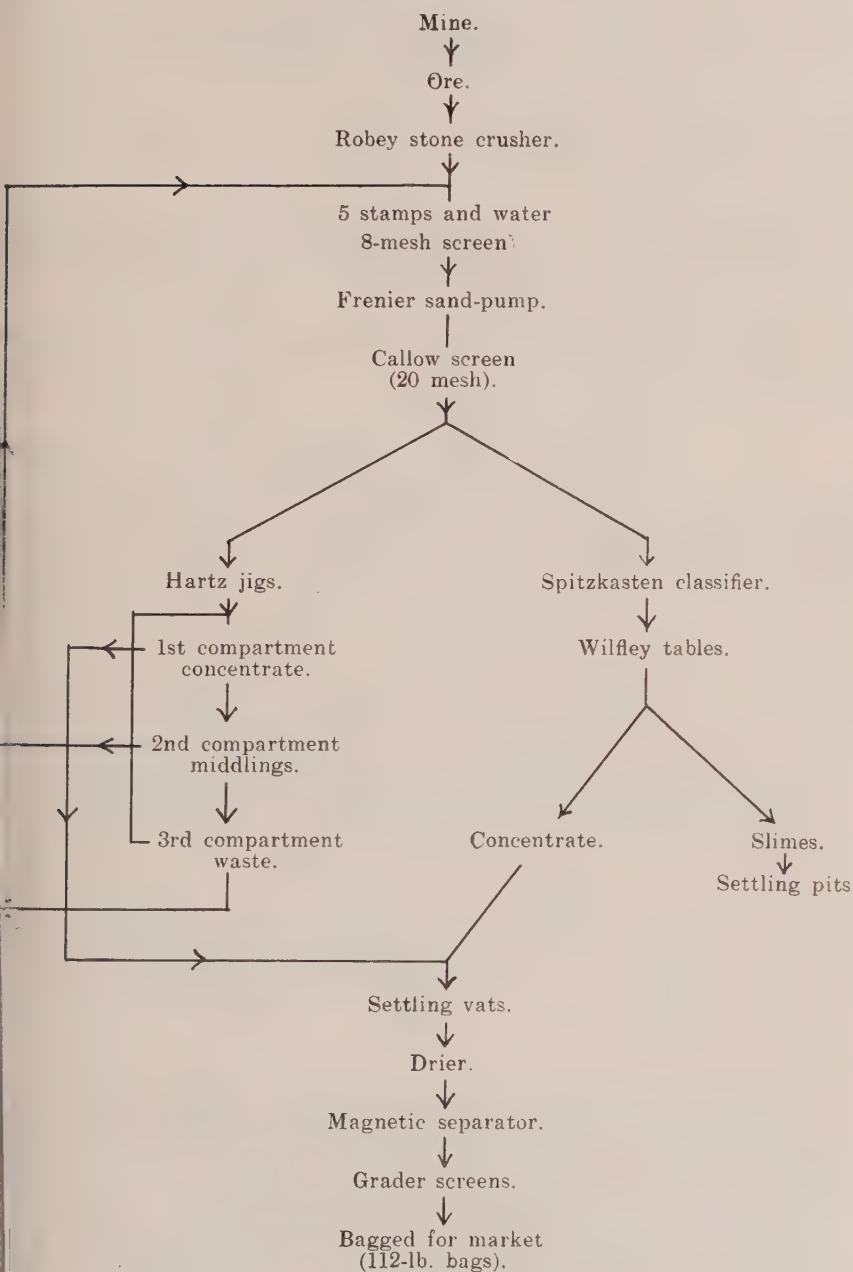
Reference must, however, be made to the attempts that have been made, since the corundum deposits of the northern Transvaal were first exploited, to produce grain corundum and a marketable corundum concentrate by mechanical milling methods. The objects of these attempts have been to utilise the large reserves of corundum present in the numerous occurrences of boulder corundum and other primary or reef deposits from which crystal corundum could not easily and profitably be recovered by the primitive methods employed by individual diggers.

On account of the high corundum-content, up to 80 per cent. by volume, of some types of boulder and their occurrence at the surface in many localities, attention was first directed towards the crushing and concentration of this material. It was, however, found extremely difficult and costly to effect a clean separation of the corundum owing to the relatively fine-grained crystallisation and the intimate intergrowth of corundum and the associated minerals in most of the types of "boulder". Some of the best boulder occurrences from the point of view of corundum-content are of the marundite and micaceous plumasite type, but when finely crushed the separation of the flaky minerals margarite and biotite from the corundum was found to be the stumbling block. The pure felspar-corundum plumasite, although containing a much lower percentage of corundum, rarely more than 40 per cent., was found to be much more amenable to treatment.

Experiments in producing grain corundum were first conducted by Messrs. Chamberlain and Setterfield in 1921 and the Zoutpansberg Grain Corundum Company was formed. This later became the Transvaal Corundum Company, and during the years 1922 and 1923 altogether about 600 tons of grain corundum were produced.

A mill was erected on the farm Turkaspost, about 6 miles west of Bandolierkop, close to a deposit of plumasite which provided the bulk of the raw material for the mill. Boulder corundum from other localities was, however, also purchased for making up the tonnage treated by the mill. The flow-sheet of the old, now dismantled, mill on Turkaspost is given below.

Flow-sheet of Mill of the Transvaal Corundum Company on
Turkaspost near Bantolier Kop, northern Transvaal.*



* Reproduced from description by Hall, Bibl. No. 6.

A satisfactory concentration giving a product of 95-96 per cent. corundum was eventually obtained in the mill but an initial mistake was made in using stamps for the crushing of the rock. This had the effect of pulverising the corundum to a large extent as well as the softer gangue minerals and consequently a relatively large proportion of " fines " were obtained in the concentrate.

In view of the fact that the coarse and intermediate grain sizes are far more widely used than the finer grades this represented a serious working loss.

The capacity of the mill was $2\frac{1}{2}$ -3 long tons of concentrate per day, and the final product was classified on slightly inclined vibrating screens into 19 grades as follows: 6, 8, 10, 12, 14, 16, 20, 24, 30, 36, 40, 46, 50, 60, 70, 80, 90, 100, and fines.

The quality of the grain corundum produced can be seen from the following analyses *:—

	I. 16 Mesh.	II. 30 Mesh.	III. 16 Mesh.	IV. 20 Mesh.	V. 40 Mesh.
Al ₂ O ₃	95.50	96.50	95.75	95.15	94.90
SiO ₂	1.20	—	1.10	1.75	2.30
Fe ₂ O ₃	0.95	1.75	1.00	1.05	1.15
TiO ₂	0.15	0.15	—	—	—
H ₂ O.....	2.20	—	1.45	1.60	1.25
	100.00	98.40	99.30	99.55	99.60

Various difficulties in connection with the milling operations and in the marketing of the product eventually arose and finally led to the cessation of operations in 1923.

In 1930 the business was reorganised as the South Africa Corundum Company and a new mill was erected at Bandolier Koppies station. Having benefited by the experience of the Transvaal Corundum Company, several improvements were embodied in the new mill. The stamps were eliminated and the crushing of the rock done in three stages by means of a jaw crusher, disc crusher and roller crusher respectively.

The concentrating section of the plant was slightly modified, but no provision for complete grading into specific grain sizes was made. The final product was sold as an ungraded concentrate, for it was ascertained that many of the consumers preferred to do the grading into sizes themselves, according to their own requirements. A sample of the concentrate of which the alumina content is over 92 per cent. was tested over standard Tyler Screens † to determine the relative proportions of the various grain sizes and gave the following results:

* Quoted from Hall. Bibl. 6.

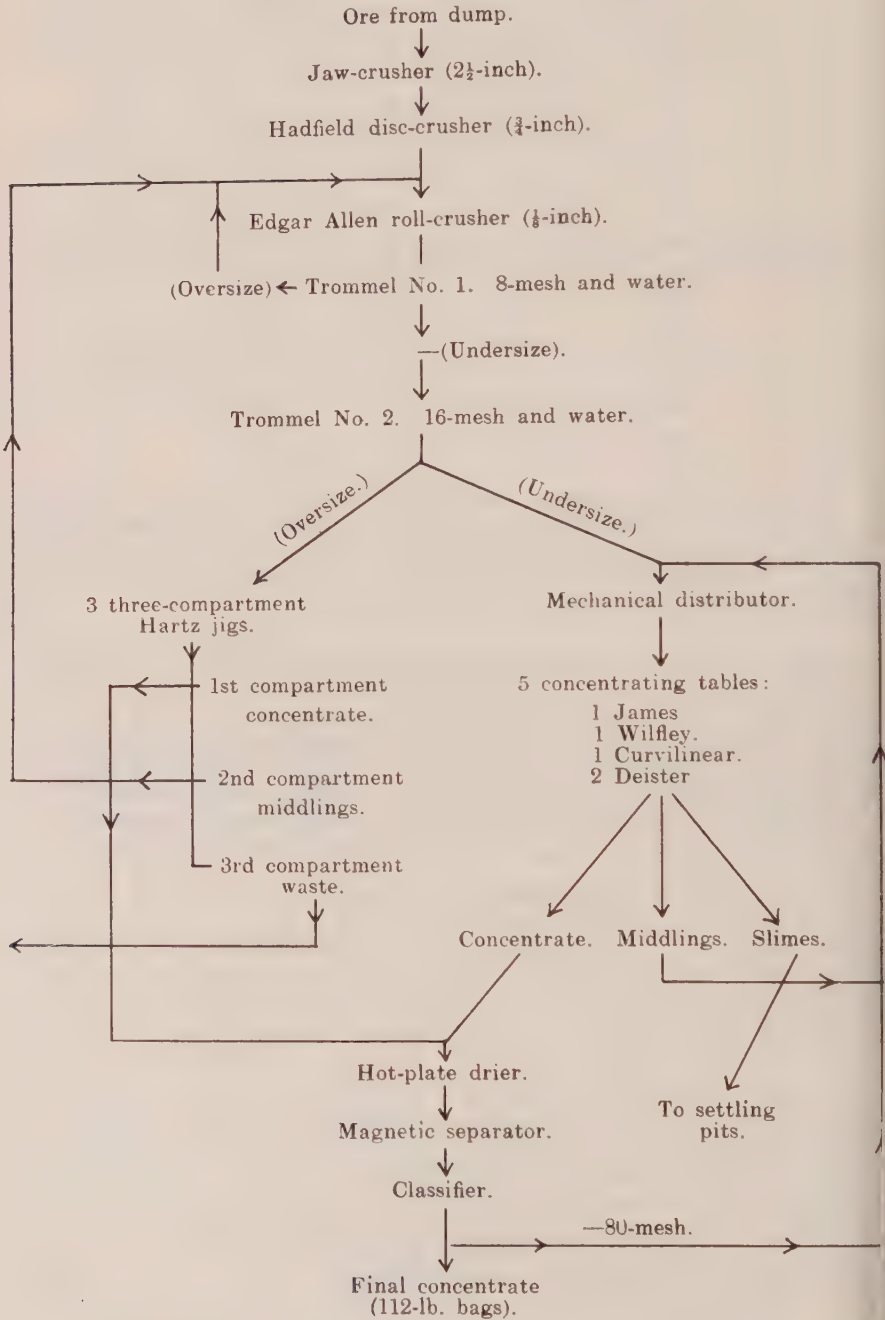
† Public Works Department Laboratory, Pretoria.

<i>Mesh.</i>	<i>Weight on Sieves (Percentage.)</i>
8	all pass
10	3.30 %
14	23.57 %
20	15.40 %
28	15.77 %
35	9.95 %
48	6.80 %
65	7.05 %
100	6.87 %
150	5.52 %
200	3.72 %
- 200	1.95 %

The proportions of the various sizes in the concentrate obtained during the period in which the mill was in operation was not constant and varied with the different types of boulder or reef corundum crushed. The plant was, however, designed and operated so as to produce as little of the fine sizes as possible.

The c.i.f. London value of the product during 1931 is stated to have been about £15. No matter what type of boulder corundum was used, the jig concentrates were generally found to be of satisfactory quality, but great difficulty was experienced with the fines in getting a clean concentration over the tables. This necessitated the separation of the - 80 fines from the final concentrate and their retreatment over a separate concentrating table several times in some cases until a relatively clean product was obtained.

*Flow-sheet of the Mill of the South African Corundum Company
at Bandolier Kop, Northern Transvaal.*



The new company did not mine corundum but bought its requirements of raw material in the form of boulder and reef from various sources in the neighbourhood.

Owing to the variable character of boulder corundum from different localities, considerable difficulty was experienced in preparing a uniform concentrate. Some types of boulder corundum especially those of the marundite and micaceous plumasite types were almost impossible to clean adequately. With this plant, as with the previous one, it was found that the pure felspar-corundum plumasites were the easiest to concentrate and gave the best final product.

The recovery of corundum from plumasite and other types of corundum-bearing rocks is at present being investigated at the Minerals Research Laboratory, Johannesburg, under the direction of Prof. Stanley. The mill at Bandolier Kop has been idle since the middle of 1931 and if, as it is hoped, operations are resumed in the near future, it may be possible to recondition the mill at a reasonable cost and as a result of the research work now being done to incorporate certain improvements which would increase the efficiency of the mill and the quality of the concentrate.

CHAPTER VIII.

• USES OF CORUNDUM.

In discussing the uses of corundum and the reasons for its being a mineral of economic importance a distinction must be made between "precious" and "common" corundum.

(1) *Precious Corundum.*

On account of their rarity and inherent beauty of colour and other desirable properties, the pure, transparent and coloured varieties of corundum are among the most highly-prized of all precious stones. The well-known gemstones, rubies and sapphires, are both varieties of corundum, and flawless specimens of good colour are of great value. Burmah, Siam, Ceylon and the Kashmir are the principal sources of these gemstones. Crystals that are not quite of gem quality are used to make the so-called "jewel" bearings of watches and some types of scientific instruments.

Artificial or synthetically prepared rubies and sapphires which are similar in chemical composition, colour and other physical properties to the natural stones are manufactured in comparatively large quantities in France, Switzerland and Germany.

Although some coloured varieties, mainly pink and blue, have been found, no precious corundum of true gem quality has hitherto been discovered in the Union. It may be mentioned however that at Oosthuizen's workings near Corundum siding, on the Selati railway line, corundum with patches of a beautiful deep blue colour has been found. All the material seen by the writer is however unsuitable as a gemstone on account of polysynthetic twinning, the pre-

sence of small inclusions and the consequent lack of the requisite transparency. It is however possible that careful search may eventually lead to the discovery of some stones of gem quality.

(2) *Common Corundum.*

The ordinary or common variety of corundum such as that which is found and produced in South Africa is of commercial importance chiefly on account of its application in industry as an abrasive and as a raw material for the manufacture of abrasive products.

Within recent years some other uses for it have been found, which although not yet well established may in time develop into important outlets for the mineral. Among these may be mentioned the use of corundum as a refractory and in the manufacture of non-slip treads for stairs, platforms, pavements and floors of public buildings, such as railway stations, which carry a large volume of pedestrian traffic.

(a) *Corundum as an Abrasive.*—The use of corundum as an abrasive is based on its hardness which is second only to that of the diamond. Corundum is in fact the hardest mineral found in nature in sufficiently large quantities to justify widespread industrial usage.

All corundum is not of equal hardness and the qualities which determine its value as an abrasive have already been described in a previous chapter (see page 35). The most important of these besides the actual hardness is the ability of breaking, when crushed, into angular fragments with sharp cutting-edges. The continued importation and use of South African corundum by manufacturers of abrasive products in the United States of America in spite of the competition of artificial corundum and other abrasives, testifies to the satisfactory nature of its abrasive qualities for the specific uses to which it is put.

For abrasive as well as the other minor uses mentioned, corundum, whether obtained in the crude form as "crystal", "boulder" and even as emery, is crushed and graded into various standard sizes of grains ranging from "6 mesh" to less than "200 mesh" by screening, and several superfine "F" or "flour" grades by means of air or water classification. As the coarser and middle grades have a much wider application than the fines and flour grades, crushing plants are designed so as to produce a minimum of fines. It is generally claimed that the larger crystals and fragments of corundum when crushed give a relatively larger proportion of the coarser grades than do the smaller crystals and fragments. For this reason the larger sizes of crystal corundum command a premium over the smaller sizes (see page 38).

For abrasive purposes the crushed and graded grain corundum thus produced is used in the following forms:—

- (i) As loose grain and powder, for grinding and polishing building and ornamental stones, gemstones, and glass—both optical lenses and plate-glass.

- (ii) In form of abrasive paper and cloths. The loose corundum grain is spread evenly over papers and cloths which have been previously coated with a strong adhesive. In this form it is used principally in the leather, wood and metal working industries.
- (iii) In the solid forms, such as grinding wheels and sharpening stones. In this case the corundum grains are held together by various kinds of bonding materials, such as:—

Clay and felspar giving what is known as vitrified wheels.

Sodium silicate giving what is known as silicate wheels.

Rubber and shellac giving what is known as elastic wheels.

Synthetic resins giving what is known as bakelite wheels.

The various types each have their specific uses.

Grinding-wheels and other abrasive products in which corundum is used are not yet manufactured in South Africa. For this reason it is unnecessary to discuss the processes of manufacture and the particular qualities and uses of the various products. For detailed information on these aspects of the matter the reader can be referred to the extensive literature on this subject already in existence.

The uses for which natural South African corundum has been found particularly satisfactory are described in the following chapter.

In the United States of America, which is the largest manufacturer and consumer of abrasive products, and to which over 90 per cent of the South African corundum is exported, it has been estimated that 70 per cent. is used in the manufacture of grinding-wheels, 20 per cent. as pure grain and flour used principally in the glass grinding and polishing trades, the greater proportion of the remaining 10 per cent. being for the manufacture of specially pure fused alumina.

In addition to the uses directly as an abrasive, corundum, especially the fine dust produced in crushing and also the type of corundum of somewhat inferior abrasive properties but which nevertheless contain over 90 per cent. Al_2O_3 , is converted into a high-grade aluminous abrasive by fusion and re-crystallisation. This product is known as fused alumina. On account of its purity and special physical properties due to its being allowed to cool under controlled temperature conditions it is said to be superior to natural corundum and the ordinary artificial corundum made from bauxite.

(b) *Corundum as a Refractory*.—Finely-ground corundum bonded with a small percentage of clay can be made into crucibles, and other articles of exceptionally high refractoriness.

Corundum is not used for this purpose to any great extent but from one firm in England interested in the manufacture of refractory crucibles the following specifications have been obtained. The corundum should be ground to a fineness of approximately 200 mesh and the chemical composition should fall within the following limits:—

Al_2O_3 - 89 - 90 per cent.

Fe_2O_3 - 1.5 - 2 per cent. (a slightly higher percentage is allowed).

No definite limit for the SiO_2 content is given as apparently this does not matter but there should be little or no felspar mixed with the corundum.

High grade "eluvial" crystal would probably be the most suitable type of corundum for this purpose. Corundum derived from reef or plumasite deposits invariably contains a small proportion of felspar admixed with it.

(c) *Non-slip Treads*.—For this purpose material containing 85 per cent. Al_2O_3 or even less is considered quite suitable, provided the corundum grains are of good abrasive quality so that in the course of wear the non-slip character of the surfaces is retained. Non-slip treads are made in the form of ceramic tiles by firing a mixture of corundum grains with a suitable clay bond or in the form of concrete slabs and blocks surfaced with corundum grains set in Portland cement. For the former, grain corundum down to a fineness of 120 mesh can be used. It should contain as little iron as possible; 1 to 2 per cent. is allowed but the presence of felspar apparently does not matter as it is absorbed into the bond when the tiles are fired.

In the case of cement slabs the use of corundum of a somewhat coarser grain is required (24-60 mesh). Should the use of corundum for this purpose develop to any extent, large quantities of the type required could be supplied. Boulder corundum from several localities would be eminently suitable if merely crushed and graded to the required sizes. If necessary a certain amount of rough concentration could be effected to bring up the corundum content to the required 85 per cent.

CHAPTER IX.

PROSPECTS OF CORUNDUM INDUSTRY IN SOUTH AFRICA.

(1) *Competitive Raw Materials*.

The use of natural corundum and the future prospects of the corundum industry in South Africa are intimately bound up with the industrial application of abrasives. It would be well therefore to consider briefly the place of natural corundum in the field of abrasives generally.

In its widest sense the term "abrasives" includes a large variety of materials, natural minerals as well as manufactured products, which are used in grinding, buffing and polishing operations. The

list of all such minerals is a long one and includes the diamond, corundum (both natural and artificial), crystalline silicon carbide, (carborundum, carbolon, etc.), emery, garnet, quartz, flint, glass, pumice, kieselguhr or diatomaceous earth, tripoli, rottenstone, chalk, rouge and the various other metallic oxides used for polishing, and the metallic abrasives steel shot, grit and wool.

The abrasive materials enumerated above can be classified into three classes, "hard", "intermediate" and "soft".

Corundum and emery are the principal natural hard abrasives but garnet, although much softer, can also be included.

The diamond, although it is by a long way the hardest substance known, does not come into consideration as an industrial abrasive except for certain specific purposes. The reason for this is its comparative rarity and high cost. For industrial purposes the non-transparent compact types known as "carbonado" and "bort" are used. These so-called "industrial" diamonds are used in drill bits, special cutting and turning tools, and for the trueing of grinding wheels made from other hard abrasives. It is also used in the form of dust for the polishing of diamonds and other gemstones.

Other hard abrasives are the manufactured products artificial corundum made from bauxite or the re-fusion of fine corundum dust, crystalline silicon carbide made from sand, coke, and sawdust, the metallic abrasives, rapidly chilled steel shot, steel grit and steel wool, certain varieties of massive garnet.

It has been established in actual working tests that certain of these hard abrasives are more suitable than others for specific purposes. Therefore while they are all competitive to a certain extent, each abrasive material has its own particular field of application. The type of abrasive used depends to a large extent on the material on which it is to be used.

Corundum either natural or artificial made up into vitrified wheels is preferred for grinding work on hard materials such as cast iron, steel, etc. It is chiefly used in the engineering and cutlery (including razor blades) industries. For certain special purposes pure fused alumina is considered more efficient than ordinary natural or artificial corundum. For stone, plate-glass, and lens grinding and polishing operations South African natural corundum has also been found very satisfactory.

Emery is also a competitor in this field but being an impure form of corundum mixed with magnetite, which adds nothing to its abrasive qualities, it sells at a slightly lower figure but is also less efficient than pure corundum.

For grinding work on the softer metals and alloys, and other materials such as rubber, leather, and bakelite compounds, the silicon carbide abrasives which are slightly harder and much more brittle than corundum, are generally considered to be the most efficient.

Garnet has been found to be particularly suitable for smoothing and polishing hard woods. The types of garnet used for abrasive purposes are the massive varieties of almandite and rhodolite. Garnet is used chiefly in the form of coated cloths and papers.

In the United States of America grain corundum prepared from South African crystals competes with ordinary artificial corundum made from bauxite as regards quality and price. Fused alumina made from specially purified bauxite or corundum dust is an superior abrasive but is more expensive.

Emery is a slightly inferior abrasive and is also somewhat cheaper. It is possible that certain types of boulder corundum containing 70 per cent. Al_2O_3 or more, if properly crushed and graded in South Africa, could compete with emery. Boulder corundum of this type compares very favourably with emery as regards corundum content and if little or no treatment is required beyond crushing and grading into grain sizes it could be marketed at a price well below that of pure corundum grain. If it can be ascertained whether this material is as suitable as emery for use in the abrasive industry it can be supplied in large quantities and will afford an important additional outlet for South African corundum.

It is understood that trial shipments of crushed and graded boulder are being made to England for testing. The results are being awaited with interest.

The use of abrasives has increased tremendously since the beginning of the present century and is indeed indispensable in modern industrial practice. Grinding has supplanted the lathe and machine-tools in many operations. The increase in consumption of hard abrasives has been such that it is doubtful whether the known sources of supply of the natural mineral abrasives would have been able to cope with the demand.

It is not surprising therefore that substitutes which could be manufactured from readily and cheaply available raw materials were developed. Silicon-carbide (carborundum) was discovered in 1890 by Acheson and production on a commercial scale began in 1895. Artificial corundum was first produced on a commercial scale in 1904. These two manufactured or artificial abrasives are now produced on a large scale in the U.S.A., Canada and several European countries, where cheap electric power is available and at present constitute over 60 per cent. of the total quantity of hard abrasives used in the world.

When the manufacture of silicon-carbide and artificial corundum was commenced on a large scale it was predicted that the use of natural mineral abrasives would eventually cease. This prediction was not fulfilled for it was found that for certain purposes the manufactured abrasives could not take the place of the natural mineral abrasives and for many other purposes the latter were of equal value and somewhat cheaper to produce. The production of natural mineral abrasives has continued but not on a scale commensurate with the increase in consumption of abrasives generally that has taken place since the beginning of the present century. There is no doubt that the successful production of artificial abrasives in no small measure created the demand for themselves and made possible the increased industrial use of abrasives throughout the world.

The pre-eminence enjoyed by the manufactured abrasives on the world market to-day is due to several causes:—

- (1) They are produced under controlled chemical and physical conditions.
- (2) Uniformity is guaranteed and the products can be varied if necessary to suit particular requirements.
- (3) They are made from relatively cheap and readily accessible raw materials.
- (4) They are manufactured in or near the countries in which they are used in the largest quantities.
- (5) Some of the larger manufacturers of artificial abrasives have adopted the policy of not only making the crude abrasives but also the finished article such as grinding-wheels, abrasive papers and cloths and the hundred and one other types of abrasive products. Efficient and resourceful sales organisations have also done much to place artificial abrasives in the position they hold to-day.

(2) *Manufacture of Abrasive Products in South Africa.*

The marketing of any abrasive material in the form of manufactured products, ready for use in various industries, increases its value considerably. In view of the fact that South Africa is an important producer of corundum it may seem strange that the manufacture of abrasive products, at any rate for local consumption, has never yet been attempted on a commercial scale. The reason for this is not the lack or unsuitability of the local raw material, for some vitrified grinding-wheels of good quality were made on an experimental scale several years ago by Prof. F. Tromp at the University of Pretoria. The non-existence of an abrasive manufacturing industry in South Africa is due to other causes the most important of which are—

- (1) the diversity of types of products required;
- (2) the relatively small local consumption of individual types of products;
- (3) the impracticability of an export trade in manufactured abrasive products.

The average value of abrasives and abrasive products in the form of grain, grinding-wheels, -stones, -papers and -cloths, imported into the Union during the past five years is £31,212. For 1934 the figure is £47,938. These, however, represent a large variety of products, made from various abrasives, all of which could not equally well be replaced by articles in which the abrasive agent is natural corundum. On the whole a very small proportion of the corundum exported from South Africa is re-imported in the manufactured state.

Even in the manufacture of vitrified grinding-wheels which is the largest outlet for South African corundum the proportion of those made from natural corundum to those made from artificial corundum and silicon carbide is extremely small.

In the engineering industry in South Africa the workshops of the South African Railways are the largest individual users of grinding-wheels. The total value of grinding-wheels purchased by the South African Railways and the value of grinding-wheels made from South African corundum for the past three years is as follows:—

			<i>Proportion.</i>
1933-34	£920	£390	43 %
1934-35	2,225	179	8 %
1935-36	2,011	128	6 %

Similar detailed information about other abrasive products imported is not obtainable but it is probably correct that the proportion in which natural corundum has been used exclusively or even partially is very much lower than that quoted in the case of the grinding-wheels used in the South African Railway workshops.

The main reason therefore why an abrasive manufacturing industry has not been established to make use of the locally produced natural corundum is undoubtedly that a large number of products of various types, shapes and sizes, the demand for each of which is relatively small, would have to be manufactured. The initial capital outlay for the establishing of an undertaking of this nature would be large and the manufacture of a large number of products in small quantities would mean high costs of production.

An essential condition for the success of an abrasive industry in South Africa is a very much larger home market for the various individual products than that which exists at present. Judging by the increase in value of abrasive products imported into the Union from £19,496 in 1932 to £47,938 in 1934 the consumption is rising rapidly and the time may not be far off when the establishment of a local abrasive manufacturing industry would be justified. Such an industry would at first have to concentrate on a few of the types of grinding-wheels for which the demand is greatest.

The possibility of an export trade in manufactured abrasive products must under present-day conditions be dismissed as impracticable. The long distances separating South Africa from the highly industrialised countries of the world where there is the greatest consumption of abrasives is one serious obstacle. The protective tariffs in force in most of these countries is another.

(3) *Conclusions and Recommendations.*

The conclusion arrived at after an investigation of all its aspects is that the best prospects for the future development of the corundum-producing industry lie in the direction of increasing the export trade in the various types of crude corundum and prepared abrasive grain that can be produced in the Union. The extent to which South African natural corundum will hold its own and perhaps extend its share of the abrasives market, small as it is, will depend on how far regular and adequate supplies, of uniform grade, of the various types of corundum for which a demand exists, or for which new markets may be found, can be guaranteed.

The establishment of a Government grading organisation has already done much towards ensuring that all corundum exported from the Union is up to the standard claimed for it and it is significant that no complaints have been received from consumers about the quality of the corundum since the grading and export regulations came in force at the beginning of 1931. In fact most of the corundum exported since then has been of higher grade than the minimum requirements laid down in the regulations (see pp. 37 and 38).

It only remains to be seen whether the available corundum resources of the Union are sufficient to supply the present and possibly increased future demand and if so what steps should be taken to bring about more effective development of the corundum producing industry. With this end in view the facts which have a bearing on these questions, the recommendations that suggest themselves and the conclusions that can be drawn will be discussed.

There is no doubt that in the corundum deposits of the northern and north-eastern Transvaal, from which nearly all the corundum hitherto produced has been obtained, the Union possesses a mineral asset of considerable value. The nature of the deposits and their distribution is such that no reliable estimate of even the probable reserves can be given. The deposits though relatively small individually are numerous and are known to occur over a very large area which even in recent years has been extended by fresh discoveries. In view of the soil and bush-covered nature of the country it is unlikely that all the workable deposits have been opened up. More systematic prospecting will doubtless lead to further discoveries even in the areas at present being exploited. It can therefore be stated that the reserves of corundum in the northern and north-eastern Transvaal alone are sufficient to keep the industry going for many years. In round figures 40,000 tons of corundum of the approximate value in the Union of £300,000 have been produced and sold between 1912 and the present time. Excluding the first four years when the average production was less than 100 tons per year the average output over the last 20 years has been in the neighbourhood of 2,000 tons per year, notwithstanding the slump periods 1919-21 and 1932 when production was virtually at a standstill. The recent experience of an increase in the rate of production from less than 200 tons per month to about 500 tons per month, within a year, under the stimulus of a rising demand and a slight increase in the prices paid to the diggers indicates that the productive capacity of the northern Transvaal area is greater than the normal average demand.

Besides the deposits of the northern and north-eastern Transvaal there are those of the Piet Retief district (south-eastern Transvaal), Swaziland, Natal and Namaqualand, the possibilities of which have not yet been fully explored. With improved methods of extraction and increased demand for corundum some of these deposits may at some future date be found worthy of exploitation.

It is the writer's belief that corundum will continue to be produced in the Union of South Africa as long as there is a demand for the mineral at a reasonable price.

Of the total quantity of 40,000 tons produced up to the present at least 90 per cent. has been in the form of crystal corundum derived from superficial eluvial deposits and from the upper portions of some "reef" or primary deposits from which in most cases only a portion of the corundum content could be recovered by the primitive hand-operated methods in use.

Owing to the depletion of the known eluvial deposits more attention is being paid to the "reef" deposits. At present probably about half the production is derived from "reef" deposits and in

future the proportion is likely to be higher. It is clear therefore that the recovery of corundum will become increasingly difficult and more costly as the rich eluvial deposits and the more easily worked outcrop portions of the reef deposits are worked out. On the other hand many of the reef deposits which have been abandoned owing to the difficulty of extracting the corundum by the simple, hand-operated methods in use, contain a high proportion of corundum. In order to provide to the full extent for the present and future demand for the mineral it is essential that some form of mechanical treatment be devised whereby the corundum from the numerous reef or primary deposits can be profitably recovered; the bulk of the reserves of corundum are in the deposits of this type.

In the past the percentage recovery of marketable crystal (about $\frac{1}{8}$ -inch in diameter) from the eluvial deposits has been fairly high, but the minus $\frac{1}{8}$ -inch fines have been lost. On the other hand the extraction of crystal corundum from the primary or reef deposits by the primitive methods previously described (see Chapter VII) has been extremely wasteful—in some cases the proportion recovered has been as low as 25 per cent.

Work done at the Minerals Research Laboratory in Johannesburg has shown that the primary corundum-bearing rocks from several localities can be quite easily dealt with by simple mechanical treatment. From the coarse-grained plumasites an appreciable proportion of crystal corundum can be recovered and fine corundum (i.e. minus $\frac{1}{8}$ -inch) can readily be recovered as a clean concentrate from the residue. The latter also applies to many of the finer-grained types of corundum-bearing rocks and to the minus $\frac{1}{8}$ -screenings and hutch products of the hand-jigging operations on many of the existing workings.

The experience obtained at the old Turkaspost mill of the Transvaal Corundum and subsequently at the Bandolier Kop Mill of the South African Corundum Company also proved that most of the types of primary corundum-bearing rocks, excepting some of the marundites and highly micaceous types, could yield a clear high-grade concentrate.

At present the only regular established market of any consequence is that for crystal corundum in the U.S.A. Practically all the South African corundum imported into the U.S.A. goes to one firm of abrasive grain manufacturers, where it is crushed, graded, and supplied to other consuming industries in the particular sizes and quantities of grain which they require from time to time, at prices which compare favourably with those of the artificial abrasives. The fact that the market for South African natural corundum in the U.S.A. has been maintained in spite of increasing competition from artificial abrasives is due partly to its special suitability for certain uses but also in no small measure to the existence of a single channel for its distribution and sale and the efforts of the firm in establishing the market.

The fact that South African corundum is not used in England and other European countries, where emery and artificial abrasives are almost exclusively used, is very largely due to the lack of a similar distributing and selling organisation. During the period

of the great war South African corundum was used in England in considerable quantities, but during the years of industrial depression which followed this market seems to have been lost. Some manufacturers seem to have had some unfortunate experiences with regard to the quality of regular delivery of the corundum purchased in the years prior to the enforcement of the grading and export regulations. Since then occasional shipments of boulder and grain corundum have been made but all efforts to re-establish a regular market in England and France have hitherto failed.

Crystal corundum enters the U.S.A. duty-free, whereas graded grain corundum is subject to a substantial duty. It is important, therefore, in order to retain the American market at least, that an adequate output of crystal corundum be maintained. At the same time, the recovery of corundum from the crushed and fine-grained material in the form of grain corundum should not be overlooked. If uniformity of grade and regular supplies can be guaranteed, a regular market for this type of corundum may be found in England and Europe and perhaps the East, and also in South Africa at such time when the local demand will justify the establishment of an abrasive manufacturing industry.

For the recovery of corundum from the primary or "reef" deposits by mechanical treatment, the scheme with the best chance of success would, in my opinion, have to consist of a number of small units combined with a larger central plant. The small treatment units should be of a type that could be erected and operated at a low cost, commensurate with the value and quantity of the corundum to be recovered. They should be designed primarily for the purpose of crushing hard plumasite and the recovery of as large a proportion as possible of the corundum in the rock as crystal corundum (i.e. above $\frac{1}{8}$ -inch diameter).

The remaining minus $\frac{1}{8}$ -inch portion could then be transported to the central mill, which would have a larger and more elaborate concentrating plant, for the recovery of fine-grained corundum concentrate and final classification into the various standard commercial sizes of grain corundum.

The question whether the transportation of the minus $\frac{1}{8}$ -inch residue from the outlying smaller treatment plants would be a payable proposition would have to be determined in each case. It would depend on the recoverable corundum content and the distance from the central plant. In some cases it may be found advisable to effect a partial concentration on the spot at the small outlying units so as to save on transport costs.

The crystal corundum recovered, for which there is an existing market and established local buying and exporting organisations, could be sold by the producers as at present. The residue for further concentration would have to be sold to the central plant on an agreed price per unit of corundum recovered, based on the current market price obtained for the final product.

If a number of such small mechanical treatment units could be erected at certain strategic points throughout the corundum-producing area in the northern Transvaal, so that they could be supplied

from several deposits of corundum-bearing rock, which has been proved to be amenable to treatment, within a range of about 10 miles, an assured supply of all types and grades of corundum for export could be maintained.

The location and system of operation of such units would have to be carefully considered. With regard to location, there are at least six suitable points in the northern Transvaal area alone to which adequate supplies of "ore" could be delivered from several deposits within the prescribed range of about 10 miles.

The suggested localities are:—

1. Koniggratz—to be supplied from deposits on Koniggratz, Wurthsdorp, Grootfontein, Munt, Westphalia, Witten, Borkum, etc.
2. Redhill (Ruscovich's store)—to be supplied from deposits on Redhill, Rooikop, Kroon, Carlisle, Beginsel, York, Kaalbult, Claudius Hoop, Nimmersnult, etc.
3. Near drift over Sandrivier on road between Louis Trichardt and Blaauwberg—to be supplied from deposits on Grutz Waerkum, Sliedrecht, Prosperina, Neustadt, Leyden, etc.
4. Bandolier Kop—to be supplied from deposits on Bultfontein, Turkaspost, Kaaldraai, Stukfontein, Phillipsdrift, Wyllie, etc.
5. Spitzkop (Bell's store)—to be supplied from deposits on Goedverwacht, Goedgezicht, Samenkomst, Pluts, Kalkoven, Buisplaats, etc.
6. On Beaufort, Versameling van Waters, or Langverwacht or some other suitable spot 40-50 miles east of Louis Trichardt on the road to Punda Maria—in order to tap this eastern area which contains several potentially important deposits.

The above-mentioned localities are suggested tentatively, but many others equally suitable can no doubt be named, e.g. Blinkwater, one of the largest individual producing farms from which well over 1,000 tons of corundum have already been obtained. On this one farm alone there are sufficient deposits to keep one small mechanical treatment plant going but it could also be supplied from the neighbouring farms Grootfontein, Munt, Fraaigezicht, Uitzoek, etc.

The system of operation of the scheme will have to be carefully worked out in consultation with the various interested parties, diggers, farm owners, exporters. A scheme such as this should eventually provide a suitable basis for the production and marketing of all corundum produced on a co-operative plan, and the equitable distribution of profits.

Further experimental work on the best and most economical methods of crushing and subsequent recovery and cleaning of corundum will still have to be done, and the costs of operation under conditions prevailing in the northern Transvaal will have to be ascertained. Further information on these points will no doubt be available when the investigation of these problems by the Minerals Research Laboratory is completed.

The separation of corundum from the gangue material has so far usually been done by wet methods—rotary pan, hand-jigging, etc. Owing to the lack of adequate supplies of water on some farms and the expense of transporting it over any appreciable distance, the possibilities of some method of dry concentration (e.g. Prof. Tromp's patent) may well be investigated.

The capital outlay required for the erection of even the small treatment units suggested will probably be beyond the means of the average corundum digger but may be possible under a scheme of joint ownership among a group of diggers working within the area served by the local plant. This would provide a further incentive to co-operative working, and the costs of operation of these mechanical treatment units may in the end prove to be lower than that of the slow, laborious and often wasteful methods employed at present. If this proves to be the case the plant will soon pay for itself.

An alternative suggestion to that of more or less permanent mechanical units at various centres,— and one which would entail a much lower capital outlay, would be to have portable mechanically-driven crushers which could then be moved from one deposit to another to crush the rock mined and accumulated during the course of a month or so. From the crushed material the corundum could still be recovered by the present methods of screening, hand-picking and jigging and then transported for final cleaning and grading to smaller number of receiving depots such as at Ruscovich's and Bell's stores or at the principal railing points Petersburg, Louis Trichardt, Zoekmekaar, Bandalier Kop and Mara.

It has been pointed out that in the past the tendency among diggers is to move further afield, away from the areas at first worked near the railway, in search of new and easily worked eluvial deposits. In this way, deposits up to 90 miles away from the railway have been opened up. With the introduction of mechanical methods of treatment the movement will be in the opposite direction, and it will be possible to re-open many of the old and previously abandoned "reef" workings nearer to the railway, thereby reducing transport charges.

In addition to taking the crushed and partly concentrated residues from the smaller treatment units the larger central plant could treat by direct fine crushing the fine-grained types of plumasite and other corundum-bearing rocks, from which crystal corundum can not be recovered, to produce an ungraded marketable concentrate or classified grain corundum. It could also undertake the direct crushing and grading of boulder corundum for which there are good prospects of finding an appreciable market.

Material from the various sources, mentioned above, would ensure an adequate supply of some material but would not necessarily mean a duplication of crushing and concentrating machinery. The various products turned out in a central plant, of the type envisaged in the suggested scheme, would vary only in the degree of concentration affected and the grain size of the final concentrate prepared. The size and working capacity of the central plant would depend on the demand for its products and the supply of raw material. A plant

capable of turning out about 100 tons of marketable corundum per month could under present conditions be amply supplied with raw material and would probably be large enough to provide for reasonably low working costs and a fair return on the initial capital required.

The existing plant of the S.A. Corundum Company at Bandolier Kop which has been idle for some years, if reconditioned and slightly modified will probably be found to be quite suitable for immediate requirements.

It has been emphasised that there is an established market for crystal corundum but that alone is not sufficient. For the continued development of the corundum producing industry on a sound and lasting basis it is essential that profitable outlets be found for the other types of corundum that can be produced if the industry is organised on the lines suggested.

In the foregoing remarks an attempt has been made to point out the many problems connected with the corundum-producing industry in South Africa. The effective utilisation of the corundum resources of the Union will be achieved only when a satisfactory solution to each one of them has been found.

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APPENDIX No. 1.

LIST OF FARMS in the Northern and North-Eastern Transvaal on which Corundum

- (a) is being worked,
- (b) has been worked,
- (c) is known to occur,
- (d) has been reported to occur.

The letters in the fourth column refer to the type of Corundum, viz. :—

E = " Eluvial " Corundum.

R = " Reef " Corundum.

B = " Boulder " Corundum.

This list has been compiled from the information obtained from a number of independent sources :—

1. Geological Survey Memoir No. 15: " Corundum in the Northern and Eastern Transvaal ", by A. L. Hall, Pretoria, 1920.
2. Records in the Office of the Mining Commissioner, Pietersburg.
3. Private records of and personal communications from a number of individuals directly or indirectly connected with the corundum industry in the Northern Transvaal.
4. Records in the Office of the Geological Survey, Pretoria, and the writer's own observations during several visits to the corundum-producing areas.

<i>Name of Farm.</i>	<i>No.</i>	<i>Magisterial District.</i>	<i>Type of Corundum.</i>	<i>Source of Information.</i>
Albasini	1085	Zoutpansberg	?	3
Altenburg	749	Pietersburg	?	2
Alverton	951	Zoutpansberg	E. and R.	3 and 4
Ameland	1055	Pietersburg	E.	3
Amesfoort	2222	Zoutpansberg	E.	3
Amsterdam	366	Letaba	E.	2
Amsterdam	727	Zoutpansberg	E.	2 and 4
Annaskraal	45	Zoutpansberg	E. and R.	3 and 4
Arras	720	Zoutpansberg	E., R. and B.	3 and 4
Archie	532	Letaba	E. and R.	2
Arundel	483	Letaba	E. and R.	2
Avondale	93	Pietersburg	E.	3
Avon	1058	Pietersburg	E.	3
Ballymore	106	Zoutpansberg	E., R. and B.	1, 3 and 4
Balmoral	187	Zoutpansberg	?	1
Bandolierfontein	154	Letaba	?	2
Barend	1089	Zoutpansberg	R.	3 and 4
Baviaanskloof	912	Zoutpansberg	E., R. and B.	1
Baviaanspoort	752	Pietersburg	?	1
Beaufort	75	Zoutpansberg	E. and R.	3 and 4
Beginsel	185	Zoutpansberg	E., R. and B.	3 and 4
Bellevue	723	Zoutpansberg	E., R. and B.	3 and 4
Bellevue	756	Pietersburg	E. and R.	3 and 4
Benaudheid	838	Zoutpansberg	E., R. and B.	1 and 4
Blaauwkop	1097	Zoutpansberg	?	3
Blinkwater	9	Letaba	E.	3
Blinkwater	1037	Pietersburg	E., R. and B.	3 and 4
Bloempjesvlei	751	Pietersburg	?	2
Blydschap	834	Zoutpansberg	E., R. and B.	3
Bochem	1018	Pietersburg	?	3
Bodensteinschoop	1982	Pietersburg	?	1
Bok	915	Pietersburg	?	1

<i>Name of Farm.</i>	<i>No.</i>	<i>Magisterial District.</i>	<i>Type of Corundum.</i>	<i>Source of Information.</i>
Bonne Esperance	840	Zoutpansberg	E. and R.	1, 3 and 4
Bontveld	36	Zoutpansberg	E.	1
Borkum	1019	Pietersburg	E. and R.	2, 3 and 4
Bornst	747	Zoutpansberg	E., R. and B.	3 and 4
Boschbokhoek	787	Pietersburg	E. and R.	3 and 4
Boschkopje	340	Zoutpansberg	E. and R.	3 and 4
Boschluiskloof	943	Zoutpansberg	E. and R.	1
Bottelput	996	Zoutpansberg	?	1
Bouw	722	Zoutpansberg	E., R. and B.	3 and 4
Brakspuit	134	Pietersburg	E. and R.	2, 3 and 4
Brandhoek	975	Zoutpansberg	E.	1
Buiksloot	1053	Pietersburg	E., R. and B.	3 and 4
Buishoek	1004	Zoutpansberg	E. and R.	3 and 4
Buisplaats	994	Zoutpansberg	E. and R.	3 and 4
Bultfontein	863	Zoutpansberg	E., R. and B.	1, 2, 3 and 4
Burg	1038	Pietersburg	E.	3
Bushy Park	208	Zoutpansberg	E.	3 and 4
Caledon	21	Zoutpansberg	E.	3
Cambrais	728	Pietersburg	E. and R.	3 and 4
Carlisle	2247	Pietersburg	E.	3 and 4
Cassel	828	Zoutpansberg	E. and R.	3
Cherbourg	653	Zoutpansberg	E.	3
Claraskraal	46	Zoutpansberg	E.	1
Claudius Hoop	22	Zoutpansberg	E., R. and B.	3 and 4
Cleadon	1934	Pietersburg	E. and R.	3
Combrow	1005	Pietersburg	E. and R.	3
Commissiedraai	871	Pietersburg	E. and R.	3 and 4
Connaught	495	Zoutpansberg	?	3
Crystallfontein	11	Zoutpansberg	E.	3
Crystalwater	49	Letaba	?	2
Cumbrae	1020	Pietersburg	E., R. and B.	2 and 4
Dalmeny	1043	Pietersburg	E.	1
De Droom (The Droem)	746	Zoutpansberg	E.	3 and 4
Deelfontein	836	Zoutpansberg	E. ?	1
De Elbe	319	Letaba	E., R. and B.	3 and 4
De Hoop	174	Zoutpansberg	E. and R.	2, 3 and 4
De Loskop	127	Pietersburg	E.	3
Diepdrift	545	Zoutpansberg	E. ?	1 and 2
Diepkloof	898	Pietersburg	E. ?	1
Donkerhoek	1930	Pietersburg	E., R. and B.	3 and 4
Doornenwaard	654	Zoutpansberg	E. and R.	3 and 4
Doornhoek	1677	Pietersburg	E. and R.	3
Doornspruit	199	Zoutpansberg	E.	1
Doreen	218	Letaba	E. and R.	3 and 4
Drensteinpest	1028	Pietersburg	E.	3
Dresden	550	Zoutpansberg	E.	1
Driefontein	358	Pietersburg	E. and R.	1
Driefontein	1928	Pietersburg	E. and R.	3
Duikershoek	943	Zoutpansberg	E.	2
Duvenhagespan	2243	Pietersburg	?	3
Dzwerani	1322	Zoutpansberg	E.	1, 3 and 4
Edna	459	Zoutpansberg	E. and R.	3 and 4
Engelberg	1047	Pietersburg	E.	1
Enkelput	1751	Pietersburg	E.	2
Excellence	309	Letaba	E., R. and B.	1, 3 and 4
Flurian	461	Zoutpansberg	E.	1, 3 and 4
Fraaigzicht	1038	Pietersburg	E., R. and B.	3 and 4
Frank Mennie	1229	Zoutpansberg	E., R. and B.	3 and 4

<i>Name of Farm.</i>	<i>No.</i>	<i>Magisterial District.</i>	<i>Type of Corundum.</i>	<i>Source of Information.</i>
Gaaroskraal	51	Zoutpansberg	E.	3 and 4
Garth	460	Zoutpansberg	E. and R.	3 and 4
Geraldine	866	Pietersburg	E.	3 and 4
Goba	914	Zoutpansberg	E.	2 and 3
Goedehoop	223	Pietersburg	E.	3 and 4
Goedgedacht	990	Zoutpansberg	E. and R.	3 and 4
Goedverwacht	957	Zoutpansberg	E., R. and B.	3 and 4
Gomorrha	764	Zoutpansberg	E.	3 and 4
Gordon	929	Zoutpansberg	E. and R.	3 and 4
Goring	643	Zoutpansberg	E.	3
Goudplaats	1580	Pietersburg	E.	1 and 2
Grietje	217	Letaba	?	1
Grobler	419	Pietersburg	E. and R.	1
Groenkloof	994	Zoutpansberg	E.	1, 3 and 4
Grootfontein	1025	Pietersburg	E. and R.	3 and 4
Groothoek	753	Pietersburg	?	3
Gruispan	218	Zoutpansberg	E.	1
Grutz	740	Zoutpansberg	E., R. and B.	1, 3 and 4
Hartebeestfontein	27	Letaba	E.	3
Hartebeestpan	212	Zoutpansberg	E.	3
Helderwater	42	Letaba	E.	3
Hoed	529	Letaba	?	2
Honingfontein	2578	Pietersburg	E.	3 and 4
Horst	1049	Pietersburg	E.	1 and 4
Houtrivier	993	Zoutpansberg	E.	3 and 4
Hugomond	729	Pietersburg	E., R. and B.	3
Huja	484	Letaba	?	2
Innes	1057	Pietersburg	E.	3
Inyoka	1697	Letaba	E., R. and B.	1, 3 and 4
Ireland	1225	Zoutpansberg	E., R. and B.	3 and 4
Islington	2017	Letaba	E., R. and B.	1, 3 and 4
Jackalsdraai	25	Zoutpansberg	E., R. and B.	3 and 4
Jooste	1096	Zoutpansberg	?	3
Joppa	810	Pietersburg	E.	3
Jordaan	872	Zoutpansberg	E. and R.	3
Kaalbult	1007	Zoutpansberg	E., R. and B.	3 and 4
Kaaldraai	835	Zoutpansberg	E., R. and B.	1, 3 and 4
Kalkbank	128	Pietersburg	E.	2, 3 and 4
Kalkfontein	129	Pietersburg	E.	3
Kalkgat	132	Pietersburg	E. and R.	2, 3 and 4
Kalkoven	991	Zoutpansberg	E. and R.	3 and 4
Kameelkuil	882	Zoutpansberg	E.	1
Kitchener	1070	Zoutpansberg	E. and R.	3 and 4
Klein Collie	755	Pietersburg	E.	3 and 4
Klein Kemp	2567	Pietersburg	?	1
Klipbank	1072	Pietersburg	?	1
Klipkraal	913	Pietersburg	?	1 and 2
Knopneuzen				
Location	1009	Zoutpansberg	E. and R.	2, 3 and 4
Koedoespoort	449	Zoutpansberg	E.	1
Koekoek	1007	Pietersburg	E.	3 and 4
Kommissiedraai	871	Pietersburg	E. and R.	3 and 4
Koniggratz	1023	Pietersburg	E., R. and B.	3 and 4
Kristalfontein	11	Zoutpansberg	E.	3 and 4
Kristalwater	49	Letaba	?	2
Krokodilgat	276	Zoutpansberg	E.	3 and 4
Kroon	186	Zoutpansberg	E., R. and B.	3 and 4
Kruisfontein	510	Zoutpansberg	E.	3 and 4
Kuilfontein	1671	Pietersburg	?	2
Kutamas Location	455	Zoutpansberg	E., R. and B.	1, 3 and 4

<i>Name of Farm.</i>	<i>No.</i>	<i>Magisterial District.</i>	<i>Type of Corundum.</i>	<i>Source of Information.</i>
Laatsgevonden	74	Zoutpansberg	?	2
Laatstehoop	363	Pietersburg	E. and R.	1
Langverwacht	950	Zoutpansberg	E. and R.	3 and 4
Leeuwknop	217	Zoutpansberg	E., R. and B.	1, 3 and 4
Legkraal	191	Pietersburg	?	2 and 3
Lekkergoed	531	Letaba	?	2
Lekkerlag	1665	Pietersburg	E.	3
Lemoenfontein	893	Pietersburg	E.	3
Leuchars	1048	Pietersburg	E.	1
Leyden	725	Zoutpansberg	E. and R.	3 and 4
Lillie	536	Letaba	?	2
Lilliput	842	Zoutpansberg	E. and R.	3 and 4
Lomond	1041	Pietersburg	E.	1 and 3
Lorgensry	742	Zoutpansberg	E.	2
Loskop, De	127	Pietersburg	E.	2 and 3
Lucerne	182	Zoutpansberg	E.	3
Lustgarten	1045	Pietersburg	E.	1
Lutepi	299	Letaba	?	2
Luton	1050	Pietersburg	E.	1
Maanskyn	183	Zoutpansberg	E.	3 and 4
Maclean	657	Pietersburg	E., R. and B.	1
Magdalena	216	Letaba	?	1 and 2
Mahilashoek	439	Zoutpansberg	E.	1
Maidstone	494	Zoutpansberg	E.	3
Malmesbury	33	Zoutpansberg	E.	3 and 4
Mamahilas Location	866	Pietersburg	E.	3 and 4
Mampakuil	225	Zoutpansberg	E., R. and B.	3 and 4
Mamre	457	Letaba	E. and R.	3
Mara	995	Zoutpansberg	E.	3 and 4
Maroelapan	2246	Pietersburg	E.	2
Maryland	498	Zoutpansberg	E.	3
Matok	1986	Pietersburg	E.	1
Matray	686	Zoutpansberg	E.	3 and 4
May	458	Zoutpansberg	E.	3 and 4
Meanderthal	763	Pietersburg	E.	3
Melkhoukkoppies	3	Zoutpansberg	E., R. and B.	3 and 4
Miss Emily	39	Zoutpansberg	E.	1
Moddervlei	92	Zoutpansberg	E.	1, 3 and 4
Mokeetsi	65	Letaba	?	2
Mooimeisjesdraai	891	Zoutpansberg	E. and R.	1, 3 and 4
Morelag	203	Letaba	?	1
Munt	1026	Pietersburg	E., R. and B.	3 and 4
Muzia Fera	312	Zoutpansberg	E., R. and B.	3 and 4
Myngenoegen	881	Zoutpansberg	E.	i
Nabelhoek		(see Nobelhoek).		
Naaldpunt	904	Zoutpansberg	E. and R.	3 and 4
Natkruit	857	Zoutpansberg	E. and R.	3 and 4
Natorp	1227	Zoutpansberg	E., R. and B.	3 and 4
Neanderthal	763	Pietersburg	E.	3 and 4
Nelly	40	Zoutpansberg	E.	1
Ne Plus Ultra	748	Zoutpansberg	E. and R.	3 and 4
Neustadt	724	Zoutpansberg	E. and R.	3 and 4
New Hanover	750	Pietersburg	?	2
Nieuweveld	29	Zoutpansberg	E.	3 and 4
Nimmersault	745	Zoutpansberg	E. and R.	3 and 4
Nobelhoek	76	Letaba	E. and B.	3
Nooitgedacht	5	Zoutpansberg	E. and R.	3 and 4
Nooitgedacht	308	Zoutpansberg	?	2
Norfolk	743	Zoutpansberg	E.	2 and 3
Oatlands	563	Zoutpansberg	E.	3
Onlust	1013	Zoutpansberg	E.	1
Oog-van-Doornrivier	947	Zoutpansberg	E.	1, 3 and 4
Oxton	1011	Zoutpansberg	E.	1

<i>Name of Farm.</i>	<i>No.</i>	<i>Magisterial District.</i>	<i>Type of Corundum.</i>	<i>Source of Information.</i>
Palmietfontein	227	Zoutpansberg	E., R. and B.	3 and 4
Palmietfontein	374	Zoutpansberg	E., R. and B.	1, 3 and 4
Palmyraville	685	Zoutpansberg	E.	3
Parsons	310	Letaba	E., R. and B.	1, 3 and 4
Paul	195	Letaba	?	1
Pelgrimszand	869	Zoutpansberg	E., R. and B.	3 and 4
Persie	982	Pietersburg	E. and R.	3
Phillipsdrift	226	Zoutpansberg	E. and R.	1, 3 and 4
Pickum	1052	Pietersburg	E. and R.	3
Piesangfontein	78	Zoutpansberg	?	2
Piet	1088	Zoutpansberg	?	3
Pietersburg	971	Zoutpansberg	?	3
Pluts	718	Zoutpansberg	E. and R.	3 and 4
Poplar	1008	Pietersburg	E.	3 and 4
Proserpina	719	Zoutpansberg	E., R. and B.	3 and 4
Potsdam	758	Pietersburg	E. and R.	3 and 4
Preezkloof	789	Pietersburg	?	2
Preston	2250	Pietersburg	E., R. and B.	3 and 4
Presumption	497	Zoutpansberg	E.	3
Puraspan	1051	Pietersburg	E., R. and B.	3 and 4
Rado Vorue Walda	721	Zoutpansberg	E. and R.	3 and 4
Ramasybok	979	Zoutpansberg	E. and R.	1 and 3
Redhill	24	Zoutpansberg	E., R. and B.	3 and 4
Reinland	985	Pietersburg	E. and R.	3
Rhoda	219	Letaba	?	1
Rietfontein	403	Pietersburg	E. and R.	3 and 4
Ringfontein	934	Pietersburg	E., R. and B.	3 and 4
Riversdale	933	Zoutpansberg	E.	3
Roerfontein	47	Letaba	?	2
Rooikop	23	Zoutpansberg	E., R. and B.	3 and 4
Rotterdam	365	Letaba	?	2
Rouwput	983	Zoutpansberg	E., R. and B.	1, 3 and 4
Ruigtevlei	373	Pietersburg	?	2
Salzburg	275	Zoutpansberg	E.	3 and 4
Samenkomst	956	Zoutpansberg	E., R. and B.	3 and 4
Saron	1006	Zoutpansberg	E., R. and B.	3 and 4
Schoonveld	188	Zoutpansberg	E. and R.	3 and 4
Schoonveld	986	Pietersburg	E. and R.	3
Seelig	1256	Zoutpansberg	E., R. and B.	3 and 4
Seekoegat	175	Zoutpansberg	E.	3 and 4
Seekoewater	19	Letaba	?	2
Seermooi	200	Letaba	E. and R.	3
Selati Ranch	300	Letaba	E., R. and B.	2, 3 and 4
Senthimulas Location	456	Zoutpansberg	E., R. and B.	1, 3 and 4
Sheila	220	Letaba	?	1
Silwerbank	876	Zoutpansberg	E.	1
Skaapkraal	451	Zoutpansberg	?	1
Skuinshoogte	122	Zoutpansberg	E. and R.	3 and 4
Slidrecht	741	Zoutpansberg	E. and R.	3 and 4
Sodom	992	Zoutpansberg	E.	2
Soekfontein	28	Letaba	?	2
Soekmekaar	189	Pietersburg	E., R. and B.	1, 3 and 4
Solingen	1033	Pietersburg	E. and R.	3 and 4
Solvent	245	Letaba	E., R. and B.	1, 3 and 4
Spelonkwater	927	Zoutpansberg	E.	3
Spitzkop	349	Zoutpansberg	E.	3
Square	121	Letaba	?	2
Sterckfontein	935	Pietersburg	E. and R.	3
Stettin	1024	Pietersburg	E. and R.	3
Straat	1003	Zoutpansberg	E.	3 and 4
Stukfontein	2621	Pietersburg	E., R. and B.	1 and 4
Styldrift	364	Zoutpansberg	E. and R.	1, 3 and 4
Swartkoppies	1623	Pietersburg	?	2

<i>Name of Farm.</i>	<i>No.</i>	<i>Magisterial District.</i>	<i>Type of Corundum.</i>	<i>Source of Information.</i>
Swartrand	1157	Zoutpansberg	E. and R.	3 and 4
Swartrandjes	986	Zoutpansberg	E.	3 and 4
Sywerгат	2477	Pietersburg	E., R. and B.	1
Tarentaalpan	1858	Pietersburg	E.	3 and 4
Thankerton	527	Letaba	?	2
The Droem	746	Zoutpansberg	E.	3 and 4
Transport	528	Letaba	?	2
Try	214	Letaba	?	2
Turkaspost	941	Zoutpansberg	E., R. and B.	1, 2, 3 and 4
Tweeputkoppies	97	Zoutpansberg	E.	1 and 3
Uitspanning	948	Zoutpansberg	E., R. and B.	1
Uitval	184	Zoutpansberg	E. and R.	3 and 4
Uitzoek	1635	Pietersburg	E. and R.	3 and 4
Una	437	Zoutpansberg	E.	3 and 4
Vaalkop	440	Zoutpansberg	E.	3 and 4
Vanwyksput	841	Pietersburg	E., R. and B.	3 and 4
Verzameling van Waters	119	Zoutpansberg	?	2
Vlakkloof	1992	Pietersburg	?	1
Vleifontein	338	Zoutpansberg	E.	3 and 4
Vleiland	1054	Pietersburg	E., R. and B.	3 and 4
Vliegapan	452	Zoutpansberg	E.	3
Voorschoten	726	Zoutpansberg	E. and R.	3 and 4
Voorspoed	57	Pietersburg	?	2
Vredenoord	680	Zoutpansberg	E., R. and B.	3 and 4
Vriendschapsdal	26	Zoutpansberg	E.	3 and 4
Vulpan	219	Zoutpansberg	E.	1 and 3
Vygeboomspruit	72	Zoutpansberg	E., R. and B.	3 and 4
Waagkraal	984	Zoutpansberg	E.	1
Waerkum	717	Zoutpansberg	E., R. and B.	3 and 4
Wagendrift	229	Zoutpansberg	E.	3
Waterside	1305	Zoutpansberg	E. and R.	3 and 4
Waterval	2398	Pietersburg	E.	1, 3 and 4
Wegkruip	877	Zoutpansberg	E.	1
Weistand	1040	Pietersburg	E.	1, 3 and 4
Weltevreden	1006	Pietersburg	E.	3 and 4
Weltevreden	58	Zoutpansberg	E. and R.	3 and 4
Wesel	981	Pietersburg	E.	3 and 4
Westphalia	1021	Pietersburg	E., R. and B.	3 and 4
Wildebeestkuil	213	Zoutpansberg	E., R. and B.	3 and 4
Wildebeestpan	1005	Zoutpansberg	E. and R.	3 and 4
Witrand	890	Pietersburg	?	1 and 2
Witten	1027	Pietersburg	E. and R.	3 and 4
Wolferoode	311	Zoutpansberg	E., R. and B.	3 and 4
Wuppertoe	1032	Pietersburg	E.	3 and 4
Wurthsdorp	1023	Pietersburg	E., R. and B.	3 and 4
Wycombe	655	Zoutpansberg	E.	3 and 4
Wyllie	1012	Zoutpansberg	E., R. and B.	1
York	774	Zoutpansberg	E., R. and B.	3 and 4
Zamenkomst	956	Zoutpansberg	E., R. and B.	3 and 4
Zeekoegat	175	Zoutpansberg	E.	3 and 4
Zeekoewater	19	Letaba	?	2
Zeermooi	200	Letaba	E. and R.	3
Zilverbank	876	Zoutpansberg	E.	1
Zoekfontein	28	Letaba	?	2
Zoekmekaar	189	Pietersburg	E., R. and B.	1, 3 and 4
Zwartkoppies	1623	Pietersburg	?	2
Zwartrand	1137	Zoutpansberg	E. and R.	3 and 4
Zwartrandjes	986	Zoutpansberg	E.	3 and 4
Zyverгат	2477	Pietersburg	E., R. and B.	1

APPENDIX No. 2.

RESTRICTED MINERALS EXPORT ACT, No. 35 of 1927.

CORUNDUM EXPORT AND GRADING REGULATIONS.

REGULATION No. 1.

The supervision of corundum for export shall be exercised by the Minister of Mines and Industries and, subject to his discretion, by the Chief Grader or his deputy and other graders as defined in section *eight* of the Act.

REGULATION No. 2.

Corundum for export shall be classified as (a) boulder corundum, (b) crystal corundum, (c) corundum concentrate, (d) grain corundum.

Definitions.

(a) The term "boulder corundum" shall signify any corundum-bearing rock which has not undergone any mechanical treatment except breaking to convenient size for handling and export.

(b) The term "crystal corundum" shall signify the natural crude corundum crystals derived from eluvial deposits or from weathered reef deposits *in situ*.

(c) The term "corundum concentrate" shall signify the product obtained by the crushing and concentration of any corundum-bearing rock to eliminate the waste or gangue minerals, but it shall be ungraded according to size.

(d) The term "grain corundum" shall signify concentrate described in previous paragraph further prepared and graded into definite commercial sizes.

REGULATION No. 3.

(1) *Boulder Corundum*.—The grade and quality of boulder corundum shall be indicated by the average alumina content of the consignment.

(2) *Crystal Corundum*.—The grade of crystal corundum shall be determined according to the alumina content and size, as follows:—

(a) *Alumina Content.*

A.—Containing not less than 92 per cent. Al_2O_3 .

B.—Containing less than 92 per cent. Al_2O_3 but not less than 90 per cent. Al_2O_3 .

C.—Containing less than 90 per cent. Al_2O_3 but not less than 85 per cent. Al_2O_3 .

D.—Containing less than 85 per cent. Al_2O_3 .

(b) *Size.*

(1) *Coarse*.—Oversize of round hole screen of $\frac{1}{8}$ -inch diameter.

(2) *Medium*.—Undersize of round hole screen of $\frac{1}{8}$ -inch diameter, and oversize of round hole screen of $\frac{1}{4}$ -inch diameter.

(3) *Fine*.—Undersize of round hole screen of $\frac{1}{4}$ -inch diameter, and oversize of round hole screen of $\frac{3}{8}$ -inch diameter.

(4) *Mixed*.—All oversize of round hole screen of $\frac{3}{8}$ -inch diameter.

(c) *Grades.*

The various grades of crystal corundum shall be made up and designated by Grade Symbols as follows:—

Grade.	Alumina Content.	Size.
A1	Over 92 % Al_2O_3	Coarse.
A2	" "	Medium.
A3	" "	Fine.
AM	" "	Mixed.
B1	Under 92 % Al_2O_3 , over 90 % Al_2O_3	Coarse.
B2	" " " "	Medium.
B3	" " " "	Fine.
BM	" " " "	Mixed.
C1	Under 90 % Al_2O_3 , over 85 % Al_2O_3	Coarse.
C2	" " " "	Medium.
C3	" " " "	Fine.
CM	" " " "	Mixed.
D1	Under 85 % Al_2O_3	Coarse.
D2	" "	Medium.
D3	" "	Fine.
DM	" "	Mixed.

(3) *Corundum concentrate* shall be classified according to alumina content as in the case of crystal outlined in paragraph (a) of sub-section (2) above, but shall not be graded according to size.

(4) *Grain corundum* shall be classified according to alumina content as in the case of crystal outlined in paragraph (a) of sub-section (2), and shall be graded into various commercial sizes of grain determined by the manufacturer or exporter subject to the approval of the Chief Grader.

REGULATION No. 4.

In establishing the grade of a consignment of corundum for export:—

- (1) (a) The alumina content of all corundum shall be determined by assay or analysis subject to the conditions laid down in regulation No. 15.
- (b) In the case of crystal corundum the judgment of the exporter as to the quality of the corundum and the relative freedom from foreign material may be accepted by the Chief Grader or his deputy.

(2) The size classification of crystal corundum into the sizes outlined in regulation No. 3, sub-section (2) (b) shall be carried out on shaking screens or rotating trommels approved of by the Chief Grader or his deputy.

REGULATION No. 5.

(1) For the purpose of examination, inspection, assay or analysis, the Chief Grader or his deputy may abstract or cause to be abstracted such samples as he may deem necessary in the presence of the exporter or his nominee.

(2) Where samples have been abstracted at the port of loading the exporter shall be responsible to the buyer for the loss in weight.

REGULATION No. 6.

(1) Crystal corundum and corundum concentrate shall be stored, sorted and/or graded only in a store, shed or open place of storage, provided with a floor constructed of cement or other suitable material approved by the Chief Grader or his deputy and maintained in good repair.

No material other than corundum shall be stored in such a place excepting where adequate provision exists to prevent contamination. A description of the construction and location of such place of storage shall be forwarded to the Chief Grader.

(2) Inspection, examination and abstraction of samples from a consignment for export shall, subject to the provision in sub-section (3) hereof, be conducted at the place of storage specified in sub-section (1) hereof.

(3) Inspection, examination and abstraction of samples for export may also be conducted at the port of export even if previous inspection, examination or abstraction of samples had taken place in terms of sub-section (2) hereof.

REGULATION No. 7.

For the purpose of inspection, examination or abstraction of samples of a consignment for export at a storage place specified, the whole consignment shall be available, and in the case of a consignment at the port of loading a minimum quantity of 5 per cent. of the total consignment.

REGULATION No. 8.

Unless permission has been specially granted by the Chief Grader or his deputy to ship in bulk, every consignment of crystal corundum and corundum concentrate for export shall be packed in suitable containers capable of withstanding reasonable handling in transit.

Where bagging is resorted to, the contents of no bag shall exceed 230 lb. in weight.

Up to a weight of 150 lb., new strong single jute bags may be used, but for weights over 150 lb. double bags shall be used, provided that the Chief Grader may permit single bags to be used for weights above 150 lb., subject to such conditions as he may require to be observed.

All bags used as containers for corundum for export shall be free from any patent defects and on the outer side free from any markings other than those required by regulation No. 9.

Samples of bags to be used for corundum export shall be supplied by the exporter, free of cost, to the Chief Corundum Grader or his Deputy for purposes of test and record.

REGULATION No. 9.

All containers of corundum for export shall be marked with durable marking:—

- (1) (a) In the case of crystal corundum with grade symbol as detailed in regulation No. 3, sub-section (2) (c).
- (b) In the case of corundum concentrate with the symbol indicating the alumina content as detailed in regulation No. 3, sub-section (3), and the word "ungraded".
- (c) In the case of grain corundum, with the symbol indicating the alumina content as detailed in regulation No. 3, sub-section (4) together with the word "grain" and the grain size number.
- (2) With the recognized mark of the exporter.
- (3) With such marks as are necessary to indicate the destination of the consignment.
- (4) With the mark "Produce of the Union of South Africa".

REGULATION No. 10.

Any person or persons intending to export corundum shall apply in writing to the Chief Grader or his deputy on the form prescribed in Schedule A for a Certificate of Export at least 14 days prior to railing.

REGULATION No. 11.

(1) Where notice has been received in terms of regulation No. 10, the Chief Grader or his deputy may pass the consignment for export on the strength of the declaration of grade by the exporter in the application submitted in terms of that regulation.

(2) The Chief Grader or his deputy may elect to examine or inspect the consignment in person before passing it.

REGULATION No. 12.

(1) Where the Chief Grader or his deputy has passed a consignment for export he shall immediately issue to the exporter a certificate of export in duplicate on the form prescribed in Schedule B hereto.

(2) In no case shall a definite statement of the Al_2O_3 content be included in the certificate of export unless it has been determined in accordance with regulation No. 4, sub-section (1) (a).

(3) A certificate of export shall automatically lapse when the consignment referred to on the certificate remains in the place of storage for a period exceeding thirty days from the date of issue of the certificate, but such period may be extended upon application to the Chief Grader at his discretion.

(4) If in the opinion of the Chief Grader or his deputy reasonable grounds exist for assuming that a consignment has been tampered with after a certificate of export has been issued, or that from any cause the consignment or any portion thereof is not in accordance with the certificate issued, he may further examine or cause to be examined the whole consignment if he finds further examine or cause to be examined the whole consignment or any portion thereof and shall cancel the certificate if he finds that the consignment is not in accordance therewith.

REGULATION No. 13.

(1) No consignment shall be tendered for railing for export at a railway station or siding unless a certificate of export, as mentioned in regulation No. 12 (1), has been issued in respect thereof.

(2) When a consignment has been placed on rail for export at a railway station or siding the exporter or his nominee shall immediately complete the form prescribed in Schedule C hereto and forward it to the Chief Grader, together with a copy of the consignment note and copies of assay certificates.

(3) When the consignment is finally shipped, the exporter or his nominee shall immediately forward a copy of the bill of lading issued in respect of the shipment to the Chief Grader.

REGULATION No. 14.

(1) When the grade of a consignment has been established in terms of regulation No. 4 (1) and the opinion of the Chief Grader or his deputy differs from that of the exporter on the question of the grade thereof a Certificate of Export shall be withheld pending determination by assay or analysis of samples taken by the Chief Grader or his deputy in terms of regulation No. 5, or further examination by the direction of the Chief Grader or his deputy.

(2) After such assay or analysis or further examination a certificate of export in accordance with its grade shall be given on the result thereof, or the exporter may withdraw the consignment and, after regrading, resubmit it for export.

REGULATION No. 15.

Any assay or analysis mentioned in these regulations shall be conducted by the Government Chemical Laboratories, Division of Chemistry, or by a certified assayer or qualified analytical chemist approved of by the Chief Grader or his deputy, and the cost thereof shall be borne by the exporter.

REGULATION No. 16.

Exporters of corundum shall keep check samples of the various grades in the consignments exported, together with their assay certificates, which may be called for by the Chief Grader or his deputy at any time up to one year after the date of shipment.

REGULATION No. 17.

No consignment of corundum shall be exported from the Union unless it conforms with the provision of these regulations.

SCHEDULE A.

UNION OF SOUTH AFRICA.

The Chief Grader,
Department of Mines and Industries,
Pretoria.

APPLICATION FOR CERTIFICATE OF EXPORT OF CORUNDUM.
(In terms of regulations framed under the Restricted Minerals Export Act,
No. 35 of 1927.)

I hereby wish to apply for a Certificate of Export for a consignment of
.....Corundum hereunder described:—

Grade.	Estimated Quantity.	Railing Point.
.....		
.....		
.....		
.....		

Per S.S.....from.....

Approximate date of sailing.....

.....
Exporter.

SCHEDULE B.

UNION OF SOUTH AFRICA.

CERTIFICATE OF EXPORT OF CORUNDUM.

(In terms of regulations framed under the Restricted Minerals Export Act,
No. 35 of 1927.)

Certificate No.....

Permission is hereby granted to export a consignment of Corundum here-
under described:—

Exporter.....

Date of application for Certificate of Export.....

Grade.	Quantity.	Railing Point.
.....		
.....		
.....		
.....		
.....		

Remarks.....

.....

.....

.....

.....
Chief Grader.

Date.....

Pretoria.

SCHEDULE C.

UNION OF SOUTH AFRICA.

The Chief Grader,
 Department of Mines and Industries,
 Pretoria.

NOTIFICATION OF RAILING OF CORUNDUM FOR EXPORT.

(In terms of regulations framed under the Restricted Minerals Export Act,
 No. 35 of 1927.)

A consignment of.....Corundum hereunder described,
 under Export Certificate No....., has been railed from.....
 to.....

Date of railing.....

Grade.	No. of Bags.	Weight.	Value f.o.r.	Truck No.
.....				
.....				
.....				
.....				
.....				

Remarks.....

.....

.....
 Exporter.

APPENDIX No. 3.

BUYERS AND EXPORTERS OF CORUNDUM IN N. AND N.E. TRANSVAAL.

The following is a list of buyers and exporters of corundum in the Transvaal:—

- * 1. Gifter Corundum Company,
P.O. Box 36,
Pietersburg, Transvaal.
- * 2. J. G. Mitchell,
P.O. Box 38,
Louis Trichardt, Transvaal,
- † 3. S.A. Corundum Co.,
P.O. Box 1174,
Pretoria.
- ‡ 4. S. J. Joel,
P.O. Box 907,
Pretoria.

In addition to the above there are the following buyers:—

- (a) C. Chamberlain, Louis Trichardt.
- (b) A. Ruscovich, P.O. Abrasive, via Pietersburg.
- (c) C. Bell, P.O. Hout Rivier, via Mara, Zoutpansberg District,

who have in the past exported on their own account but who at present dispose of their corundum in the case of (a) and (b) to the Gifter Corundum Co., and (c) to J. G. Mitchell.

Producers.—Even if it were possible, no good purpose will be served by giving a list of all corundum producers in the N. and N.E. Transvaal and the farms on which they are working.

The area is large and the deposits are numerous and many diggers move from one deposit to another at frequent intervals. Furthermore, with a large number of producers, corundum digging is not their only occupation.

In view of these facts any list of producers would at best be incomplete and would soon be out-of-date.

* Purchase from small producers for export.

† Not at present producing. Sales of grain and concentrates from stocks only.

‡ Exports boulder corundum at irregular intervals.

APPENDIX No. 4.

STATISTICAL INFORMATION.

TABLE No. 1.

*Production of Corundum in the Union of South Africa.**
(Short Tons = 2,000 lb.)

<i>Year.</i>	<i>Transvaal.</i>	<i>Cape.</i>	<i>Natal.</i>	<i>Total.</i>
1912	111·000	—	—	111·000
1913	—	22·548	—	22·548
1914	—	12·432	—	12·432
1915	67·126	—	1·000	68·126
1916	769·460	—	—	769·460
1917	2,910·088	—	—	2,910·088
1918	4,138·222	71·658	—	4,209·880
1919	165·067	53·520	—	218·587
1920	225·500	46·850	—	272·350
1921	122·750	—	—	122·750
1922	2,278·557	—	—	2,278·557
1923	3,253·319	25·633	—	3,278·952
1924	1,434·100	8·750	—	1,442·850
1925	1,948·680	12·750	—	1,961·430
1926	6,034·250	15·000	—	6,049·250
1927	1,020·700	6·000	—	1,026·700
1928	1,735·250	—	—	1,735·250
1929	3,638·500	—	—	3,638·500
1930	2,686·920	—	—	2,686·920
1931	1,256·782	—	—	1,256·782
1932	361·820	—	—	361·820
1933	1,303·837	—	—	1,303·837
1934	3,202·000	—	—	3,202·000

* Obtained from office of the Government Mining Engineer, Johannesburg.

TABLE No. 2.

*World Production of Natural High Grade or Hard Abrasives—Corundum, Emery and Garnet.**

(Long Tons = 2,240 lb.)

<i>Country and Description.</i>	<i>1929.</i>	<i>1930.</i>	<i>1931.</i>	<i>1932.</i>	<i>1933.</i>
Kenya..... Corundum	(130 lb.)	(120 lb.)	—	—	—
Southern Rhodesia. Corundum	20	9	—	—	—
Union of S. Africa Corundum	3,249	2,399	1,122	323	1,164
British India..... Corundum	34	30	—	—	—
British India..... Garnet...	—	7	—	147	—
Germany..... Emery....	388	188	207	205	†
(Bavaria)					
Greece..... Emery....	10,393	12,399	11,445	8,794	†
Madagascar..... Corundum	64	92	9	(55 lb.)	—
U.S.A..... Emery....	825	496	457	223	943
U.S.A..... Garnet....	5,332	4,467	2,630	1,741	2,495
Turkey..... Emery....	7,483	3,117	3,433	6,220	6,905

† Information not available.

* Taken from "Statistical Summary" of the Mineral Industry of the British Empire and Foreign Countries, issued by the Imperial Institute, London, 1934.

TABLE No. 3.

*Crude Manufactured Abrasives, Sold, Shipped or Used, from Plants in the U.S.A. and Canada.**

Year.	Silicon Carbide.		Aluminium Oxide.		Metallic Abrasives.		Total.	
	Short Tons.	Value \$	Short Tons.	Value \$	Short Tons.	Value \$	Short Tons.	Value \$
1929	30,309	3,060,401	71,614	6,471,373	23,789	1,289,922	126,712	10,821,696
1930	22,008	2,047,188	46,465	4,067,148	16,428	977,037	84,901	7,091,373
1931	8,193	967,840	25,070	2,336,586	11,105	613,683	44,368	3,918,109
1932	11,593	1,006,064	18,835	1,400,420	8,482	410,264	38,910	2,876,748
1933	16,606	1,715,989	30,778	2,436,962	6,844	381,314	54,228	4,534,265

* Taken from Statistics of U.S. Bureau of Mines reproduced in "The Mineral Industry during 1933." Vol. 42. New York, 1934. Similar information regarding the production of artificial abrasives in European Countries is not available.

TABLE No. 4.

The imports of abrasive materials into the Union of South Africa as classified by the Department of Customs and Excise, for the past four years are as follows:—

Description.	1931.		1932.		1933.		1934.	
	Quantity lb. av.	Value. £	Quantity lb. av.	Value. £	Quantity lb. av.	Value. £	Quantity lb. av.	Value. £
Emery in bulk...	18,883	379	11,080	278	13,308	390	20,734	584
Pumice in bulk...	157,403	589	166,110	374	377,686	842	455,226	1,100
Other abrasives, N.E.E.....	—	1,509	—	1,277	—	1,522	—	4,142
Abrasive wheels..	—	9,157	—	7,289	—	12,106	—	19,381
Abrasive papers and cloths.....	—	16,599	—	10,652	—	18,100	—	23,831
Millstones.....	—	86	—	9	—	64	—	55
Oilstones.....	—	590	—	364	—	551	—	838
TOTAL VALUE...£	—	28,909	—	20,243	—	33,576	—	49,931

